MAY 1961

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ILLUMINATING ENGINEERING

Journal of the
ILLUMINATING ENGINEERING SOCIETY

ADVANCE® IMPROVED SOLID-FIL

DRIP-FREE Unitized Construction

Unretouched photograph

This cut-away view illustrates how the improved **"SOLID-FIL"** development completely encapsulates internal ballast components leaving no voids . . . forming integrated ***UNITIZED CONSTRUCTION***.

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- **QUIETER**
- **MORE EFFICIENT HEAT DISSIPATION**
- **GREATER SAFETY**

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The Advance **"SOLID-FIL"** development differs from other types of solid fill materials in that it retains a pliable consistency and will not become brittle with age or heat, permitting retention of its excellent thermal and sound deadening characteristics. Accelerated heat tests far above those experienced in an actual lighting installation, *proved conclusively no deterioration or drippage* of the Advance **"SOLID-FIL"** development.

The new Advance **"SOLID-FIL"** ballasts assure quieter operation, more efficient heat dissipation, greater safety and drip-free operation.

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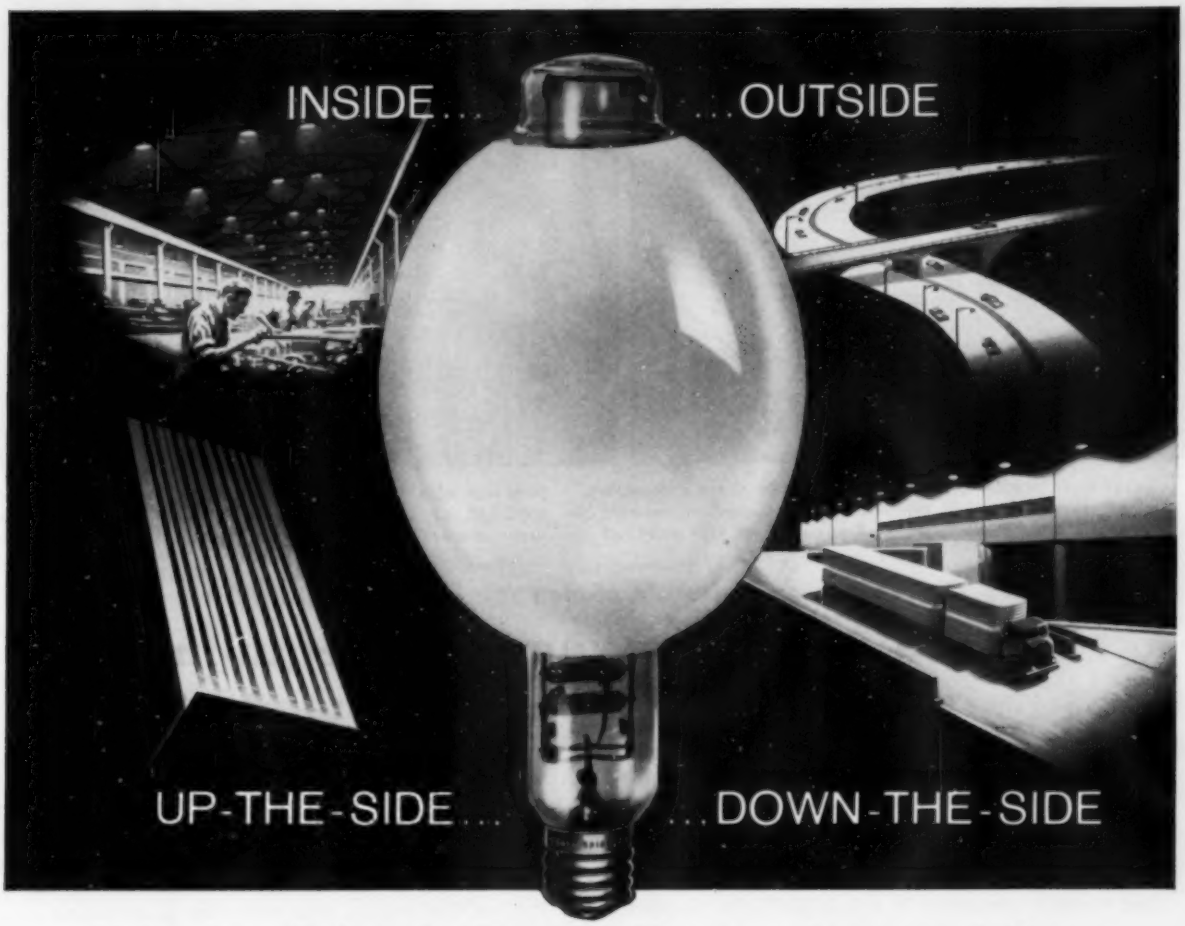

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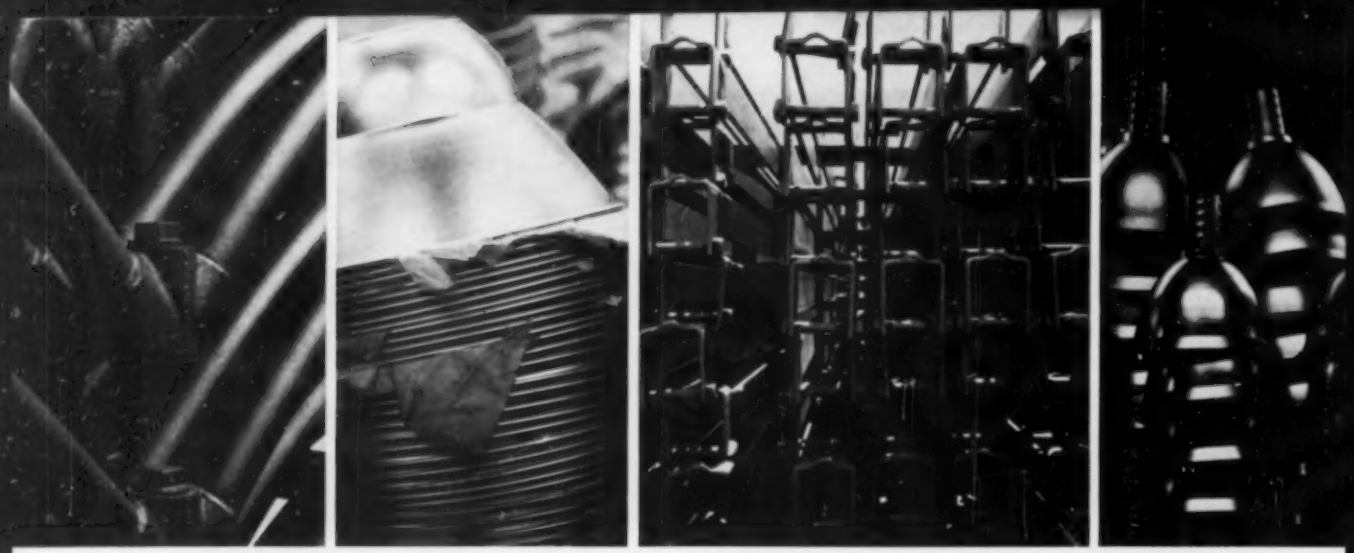

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Sleek fixture appearance complements modern wall treatment throughout building.

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Architect: *Perkins & Wills;* Electrical Contractor: *Kelso Burnett Co.*

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The result is an attractive, efficient working environment with...

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More uniform air distribution, thanks to the many diffusing sources;

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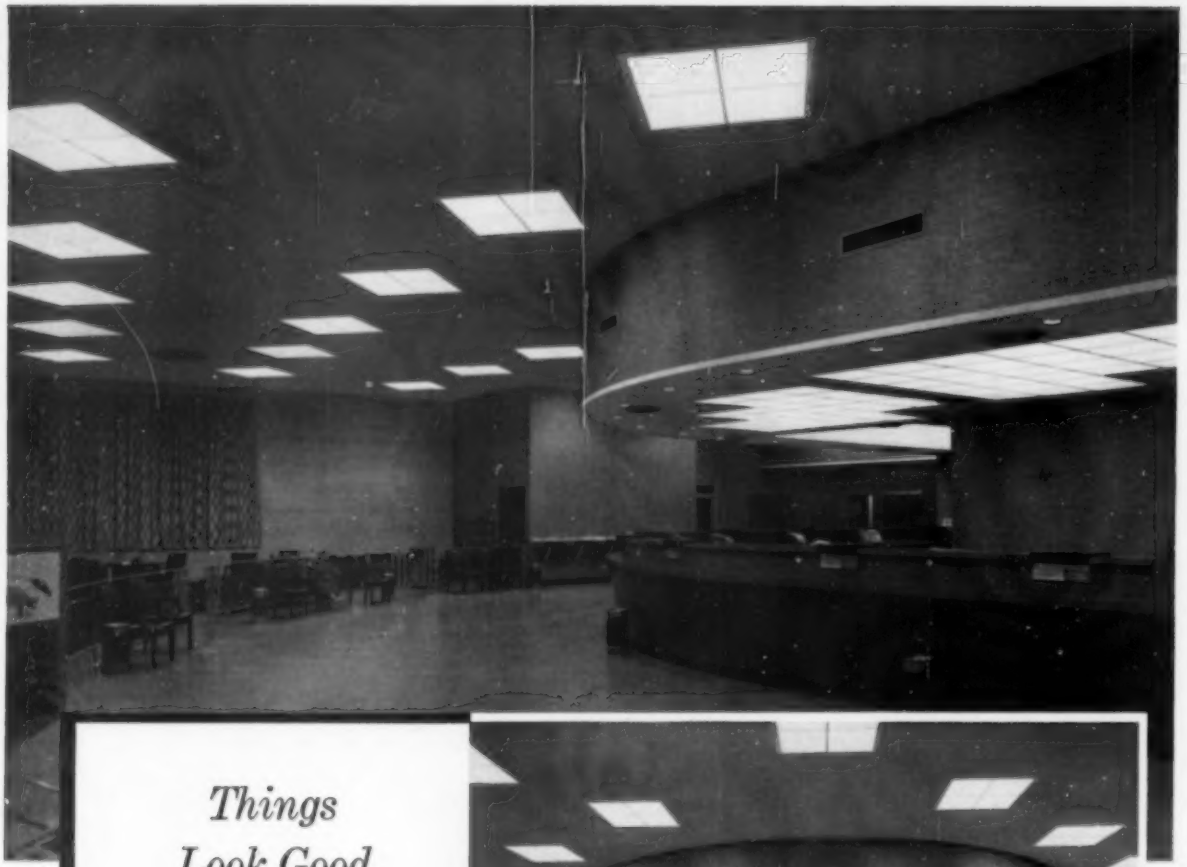

Things Look Good at the Nation's Second Oldest Bank

Here's another Litecontrol bank installation which features glamor without glare and function without frills. It's at the Slater Trust Office of the Industrial National Bank in Pawtucket, Rhode Island — a bank which traces its corporate ancestry to the Providence Bank, founded in 1791.

Fixtures are all equipped with Holophane acrylic lenses, and include a luminous lens ceiling plus 4′ x 4′ and 2′ x 4′ units. Note how the luminous lens ceiling panels are designed "round the corner" under the curved soffet, over the tellers' counters.

The 4′ x 4′ fixtures are spotted to adequately illuminate the irregular public area and officers' section. A specially designed long narrow lens fixture may be seen above the elevator in the major photo.

Think of Litecontrol for *your* next installation.

INSTALLATION: Slater Trust Office, Industrial National Bank, Pawtucket, Rhode Island.
ARCHITECT: Leonard S. Muir, Pawtucket, Rhode Island.
DESIGN ENGINEER: A. Thomson Cooksey, Pawtucket, Rhode Island.
ELECTRICAL CONTRACTOR: Crawford Electric Construction Company, Pawtucket, Rhode Island.
DISTRIBUTOR: Westinghouse Electric Supply Company, Providence, Rhode Island.
LITECONTROL DISTRICT SALES ENGINEER: Dallas G. Dearmin, 5 Hillcrest Ave., Greenville, Rhode Island.
AREA SHOWN: General Banking Area.
CEILING HEIGHTS: 15′-0″ and 10′-0″.
FIXTURES: Litecontrol Luminous Lens Ceiling panels, #4384RS-6025 8-lamp Rapid Start recessed 4′ x 4′ fixture, and #9344RS-6025, 4-lamp Rapid Start recessed 2′ x 4′ fixtures, all using Holophane acrylic lenses.
AVERAGE INTENSITY: Approximately 90 footcandles in service.

LITECONTROL
LIGHTING
LITECONTROL CORPORATION.
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DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

IDEAS . . .

for a lighting man's file

IF PROGRESS is the spread of ideas, then shop talk, whether by word of mouth or in print, is at the heart of any industry's growth. With IES committees established as the authorities on standards and general lighting design principles, each individual lighting practitioner becomes a source of ideas for solving specific installation problems. The three lighting designs presented here are not offered as models of the application of the scientific principles of illumination, although each has adhered to established standards of "quality and quantity." Their interest, for the working engineer, lies in an originality of approach which might merit repetition at some future date.

1 Daylight and Electric Light

When economics determine the adequacy of a lighting system, as in a majority of schools, libraries and other public buildings, a combination of daylight and electric light is often a solution to the twin goals of good lighting and low cost. Systems designed with this technique usually employ large areas of glass for the admission of daylight and a supplementary electric lighting system. In a novel twist on this combination at the Wethersfield, Conn. town library, both daylight and fluorescent light have been channeled into a *single* plenum to achieve highly efficient, economical and easily maintained lighting.

The main reading room of the library and a contiguous two-level book stack area are enclosed by three solid masonry walls and one glass curtain wall, adjacent to the stacks. Since the daylight diffused through the curtain wall provided insufficient illumination for the stacks and almost none in the main reading room, all effective lighting had to be delivered by the ceiling system.

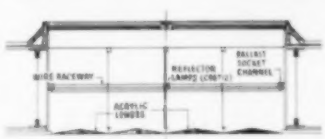
Daylight is admitted through prismatic glass block skylights and directed into plenums created through the use of space in the roof structural system. Eight-foot slimline fluorescent reflector lamps are mounted on 18-inch centers in the plenum, 18 inches above plastic acrylic lens diffusing material which provides both horizontal and transverse control of light. Construction details (see drawing below and photo facing page) involve channels attached to the skylight panel frames and a series of hanger rods suspended from these channels for the primary lens tracks. Spacer bars create 24-inch-square T-bar spaces for holding the individual acrylic lenses at ceiling level.

Use of prismatic lenses permits good control and diffusion of light with a minimum of glare; reflector lamps minimize lost upward component within the plenum. Lamps are wired on alternate circuits so that half may be used to boost daylight illumination level. After six months of operation, readings indicated 50 footcandles of daylight, 70 footcandles of fluorescent light.

To obtain maximum efficiency from the lighting system, walls above the seven-foot bookcases were birch panelled and stained with a warm pale beige, 50 per cent RF; the floor was covered with a buff-colored vinyl asbestos, 25 per cent RF. Ceiling has a reflection factor of 80 per cent and all work surfaces are light colored for good brightness balance within the viewing area.

In the stack section, single-lamp directional troffers, supplementing the daylighting, provide good illumination on the book titles. A decorative mural on an end wall is carefully lighted from below to obviate the problem of confusing highlights common to top-lighted paintings.

Lighting was designed by Jerome F. Mueller, Consulting Engineer, Hartford, Conn. Architects were Ebbets, Frid and Prentice. ■



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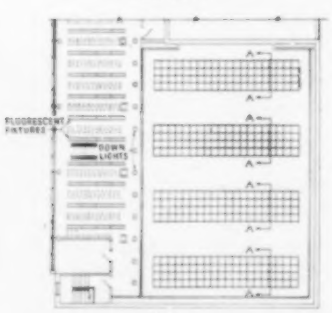
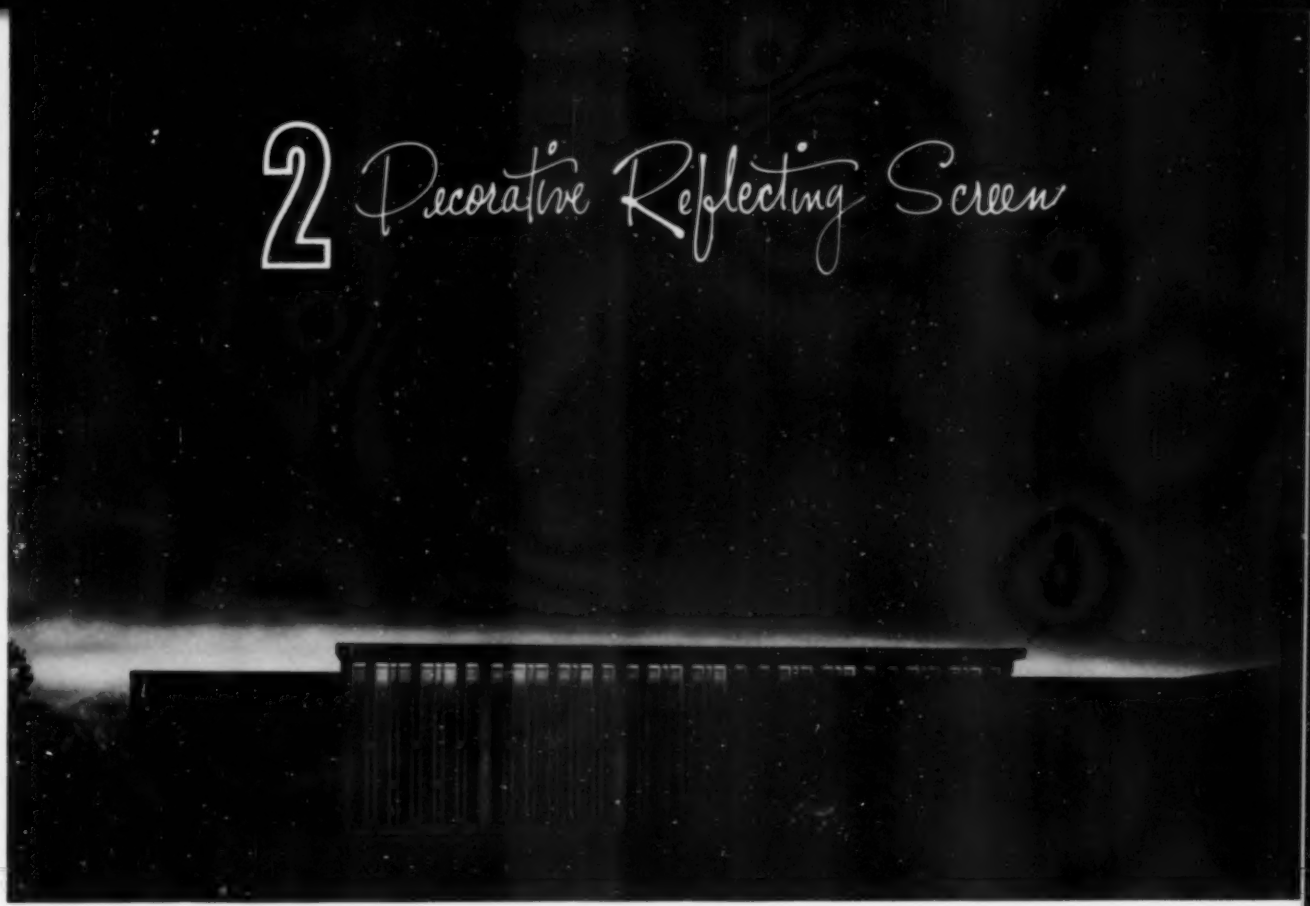
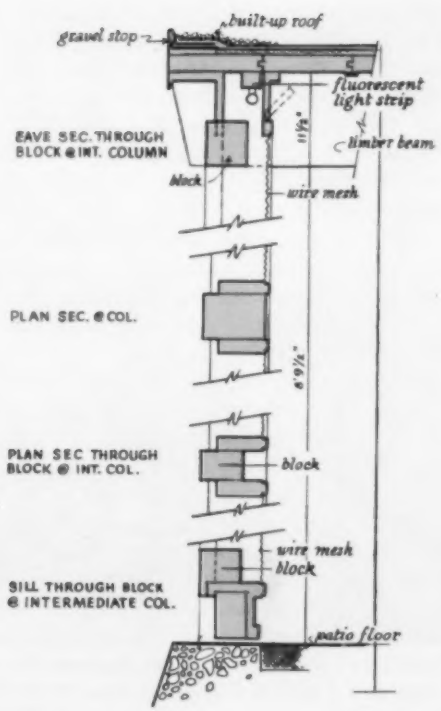


PLAN

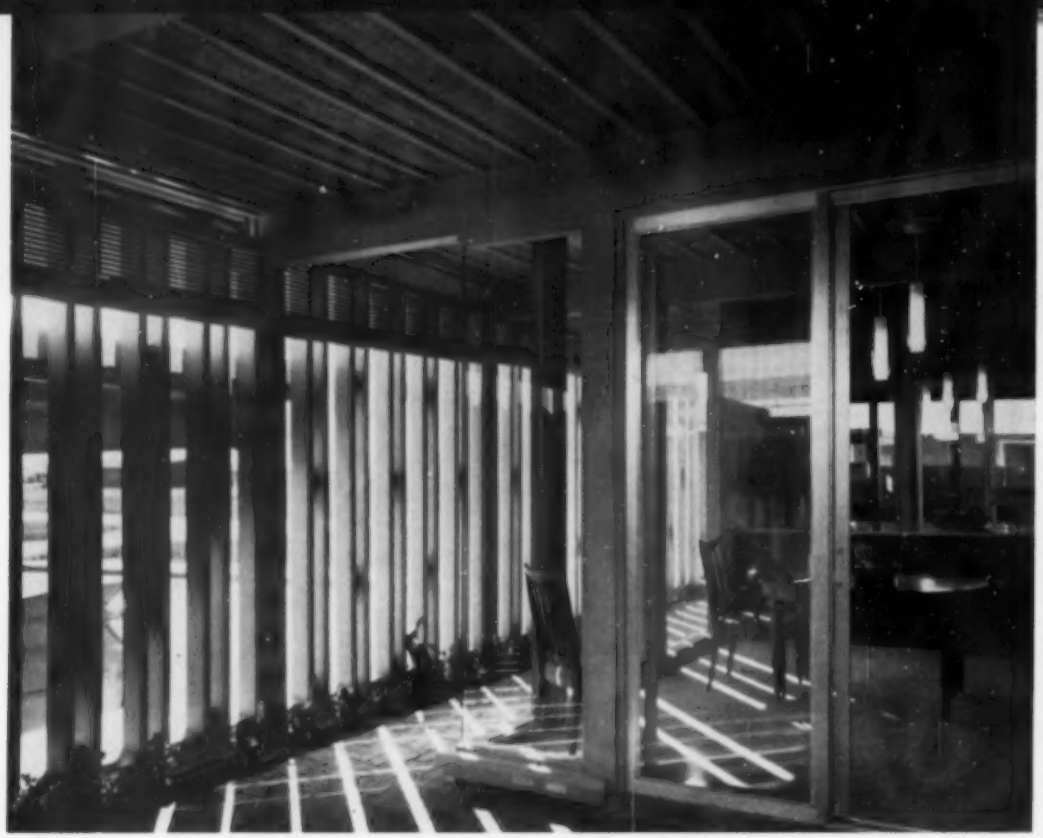
2 Decorative Reflecting Screen



Union of the functional and decorative elements is the ultimate goal of almost every lighting design, although the degree of success achieved is dependent, in large part, upon the nature of the area to be lighted. The decorative reflecting screen wall which forms the facade of the William C. Nelson



Detail of decorative reflecting screen wall.



Interior view of decorative reflecting screen wall and adjacent living area.

residence in Port Arthur, Texas, has achieved this desired unity of design in two areas—architecture and lighting.

The architectural beauty of the screen wall and the patterns of light and shadow it creates are evident from the photo on the preceding page. As a functional element, the predominantly vertical configuration of the design reduces the amount of sun penetration from the eastern exposure and restricts the vision of passers-by, assuring privacy on the patio beyond the wall. A wire mesh screen attached to the inside of the wall provides protection from insects and at the same time permits natural ventilation of the patio.

The lighting element, completely integrated into the architectural design, is a concealed indirect continuous fluorescent strip. Lamps are arranged so that light is reflected outward from the solid portion of the wire mesh, creating a glare which restricts outsiders' views at night. In addition, this single lighting element provides general illumination on the patio, exterior illumination on the facade and retains the beauty of the decorative screen after dark.

Screen wall and lighting were designed by Allan K. James of Floyd & James, Architects, Houston, Texas.

3 Simple lighting flexibility

Furniture groupings, color patterns and room dividers are adequate tools for creating a multipurpose area in a single space, but none of these techniques is as effective as variable lighting in altering moods and atmospheres.

The executive suite of the Brunswick Corp. offices in Chicago is divided into three main areas—multipurpose lounge, small lounge and bar area and executive board room. The functional versatility of these three areas, capable of being used either separately or simultaneously, for business meetings or

entertainment purposes is largely a result of the lighting design.

In the large lounge pictured below, 4- by 16-foot luminous strips of circular polystyrene louver panels housing alternate rows of white, pink and gold 40-watt T12 fluorescent lamps are installed on two sides of the room. The lamps are mounted on 12-inch centers, 12 inches above the diffusing plastic, with different color lamps separately switched for variation of lighting moods. Dimmer-controlled 150-watt baffled incandescent downlights can be combined with the various fluorescent colors for further flexibility of effects. With both fluorescent and incandescent units in use, the illumination level is 38 footcandles. White fluorescent lamps alone provide 10 footcandles; pink lamps, 5 footcandles and gold lamps, 8 footcandles. Maximum brightness of the luminous strip is 250 fL.

The bar and small lounge (not shown), separated from the large lounge by only a low partition, is lighted with three-foot square luminous sections alternated with 80 per cent RF white laminated plastic squares in a checkerboard pattern. Similar in design to the luminous elements in the large lounge, these units are equipped with circular polystyrene louver panels and alternate rows of standard cool white, pink and gold fluorescent lamps.

In both the large lounge and bar, plenum is flat white, 75 per cent reflection factor. Walnut wall panelling in the bar and on two walls of the lounge has a reflection factor of 18 per cent; end walls in the lounge, 80 per cent RF; cork floor in both rooms, 25 per cent RF. Lighting levels are variable between 5 and 25 footcandles in the lounge, 10 and 50 footcandles in the bar for a multiplicity of light-inspired moods.

The board room (not shown) at the rear of the executive suite is lighted by a luminous ceiling composed of 48-inch squares of dropped translucent plastic panels in hinged frames. Six-inch-deep tapered walnut baffles on 48-inch centers are fastened to the ceiling grid for decorative effect. Lamps are spaced on 18-inch centers, 12 inches above the diffusing materials and the plenum painted flat white, 75 per cent RF. Walnut wall panelling in this room has a reflectance of 18 per cent; beige carpeting, 25-30 per cent.

Electronic dimmer controls permit variation of lighting levels from 25 footcandles for dining to 70 footcandles for business meetings. Measured brightnesses were 320 fL at 70 footcandles, 85 fL at 25 footcandles.

All lighting was designed by Jules G. Mirot, Architect, Glencoe, Ill. ■

Large lounge features combination of dimmer-controlled fluorescent strips along perimeter and baffled incandescent downlighting in the central area. Fluorescent strips are equipped with alternate rows of white, pink and gold lamps. Wood framed marble room divider is highlighted on both sides by PAR38 lamps in recessed eyeball units.

architectural floodlighting

Even the poorest European country can find money to floodlight its beautiful buildings, monuments and fountains, while the United States cannot afford to turn on the fountain lighting in front of the Capitol Building in Washington, D. C. This indictment of decorative floodlighting in the U. S. was made at the recent National Lighting Exposition Symposiums. Although the European economy's dependence upon tourism has undoubtedly spurred floodlighting, this juxtaposition does emphasize one area where American lighting practice compares unfavorably with European.

The esthetic value of floodlighting is evident from any comparison of a floodlighted building with its darker neighbors. However, floodlighting also serves the practical purposes of providing identification and enhancing a company's public image.

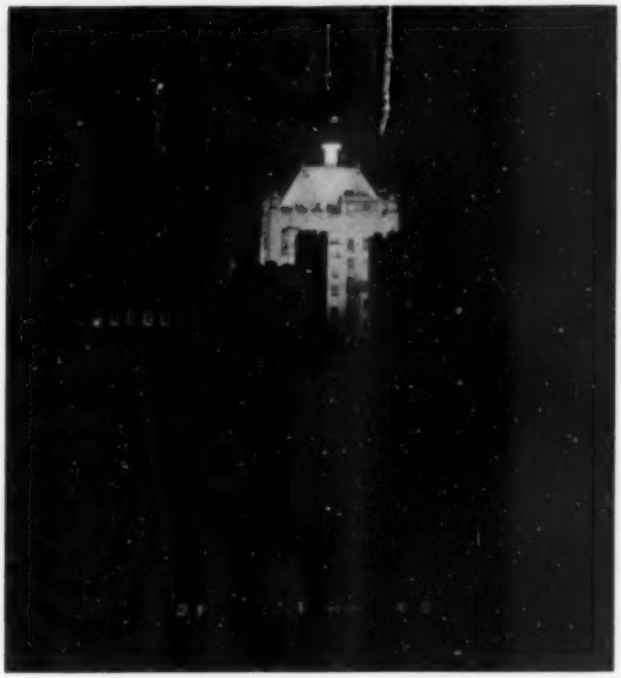
2

approaches

Floodlighting of the Wisconsin Telephone Co. building marked the company's participation in the celebration of Milwaukee's new role as an ocean-going port, following completion of the St. Lawrence Seaway. Initial use of the system, coinciding with the opening of the Seaway, was intended as an affirmation of the company's faith in the future of downtown Milwaukee.

For the American United Life Insurance Co. in Indianapolis, floodlighting was to serve several useful purposes—to prevent harried expectant mothers from mistaking the insurance building for a near-by hospital, reduce petty crimes in a dark area, eliminate a "lovers' lane" and preserve the company's identity in an area populated by more than a score of other insurance organizations.

WISCONSIN TELEPHONE CO.



Although the original design for the Telephone Co. planned floodlighting for the entire building and the use of revolving beacons, a limited budget confined the installation to four areas of the building's tower—large brick wall faces, an oxidized copper roof, glass-walled turret and a flagpole atop the turret. The final blending of three kinds of light sources—fluorescent, mercury and incandescent—to enhance the various structural materials of the tower is a tribute to artistic judgment and engineering skill.

Incandescent lighting for the reddish-brown brick walls of the three top floors of the building is from 1500-watt PS52 units mounted on a lower roof. Similar lighting arrangements for the north and south faces each use nine units with 80-degree horizontal and 74-degree vertical beam spread. The east face is flooded by 18 units, with 51-degree horizontal and 48-degree vertical beam spread, arranged in two banks of nine each. On the west face of the building, since no setbacks were available for floodlight mounting, interior lighting on the upper floors is turned on during the floodlighting period to provide some brightness. All outdoor equipment

AMERICAN UNITED LIFE INSURANCE CO.

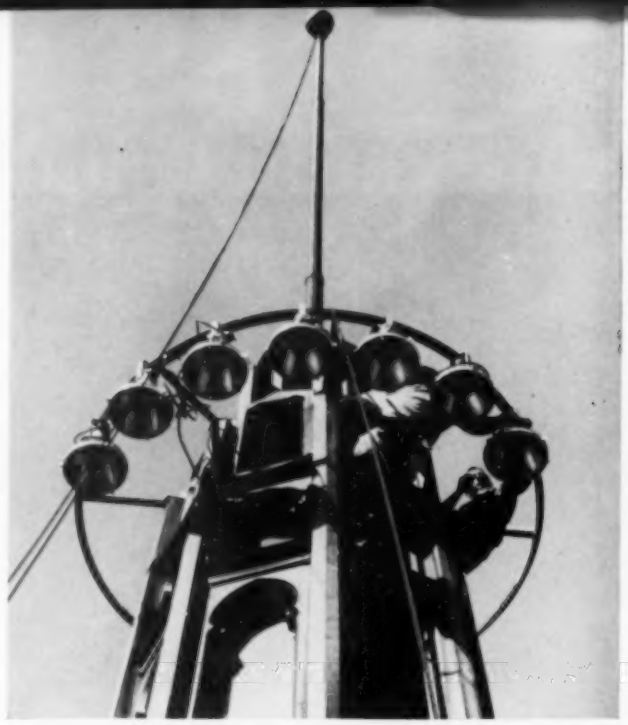
Acceptance of the floodlighting design for the American United Life Insurance building depended upon its ability to overcome three objections which had stymied previous floodlighting projects: equipment to be inconspicuous during the day; design to blend with the 1930 architecture of the building, particularly at the front entrance and upper portico; economy of installation and operation. The proposed plan, accepted by the company's board of directors without alteration, provided an average maintained lighting level of 12 footcandles on the light grey limestone building, with highlighting of 40 footcandles maintained on the entrance portico and 32 footcandles maintained on the upper portico.

Thirty-one 1000-watt floodlamps arranged around the buildings on the front lawn and targetted to provide even coverage of the facade are used for general lighting. Landscaping, which followed the completion of the lighting installation, completely conceals the equipment. The more difficult illumination of the entrance and upper portico was ac-

Wisconsin Telephone Co. (Continued)

is weatherproof and wired one per circuit to provide flexibility for mobile color, if desired. With a reflection factor of 20 per cent, lighting level is about 30 footcandles. The bluish-green color of the oxidized copper roof, intensified by the application of mercury lamps, contrasts with the warm tones of the brick walls. To obtain a good reflecting angle for roof illumination, a 10-foot diameter ring was mounted on the turret, 18 feet above the top ridge of the roof, and fitted with 18 400-watt clear, hard glass mercury units. A 30-degree beam spread confines the lumen output to the roof. Maintenance of this equipment is accomplished through the turret windows (see photo). Illumination level produced is between 30 and 50 footcandles.

The glass-walled turret is lighted from within by eight 15,000-lumen PG17 lamps mounted vertically side by side around the center core post, with one lamp positioned opposite each line of glass. Remotely located ballasts are used to retain maximum space for the lamps and still provide access



Mercury floodlights for copper roof were installed through turret windows. Maintenance is by a similar procedure. Size of ring used for mounting mercury units was determined by ease of accessibility through windows.

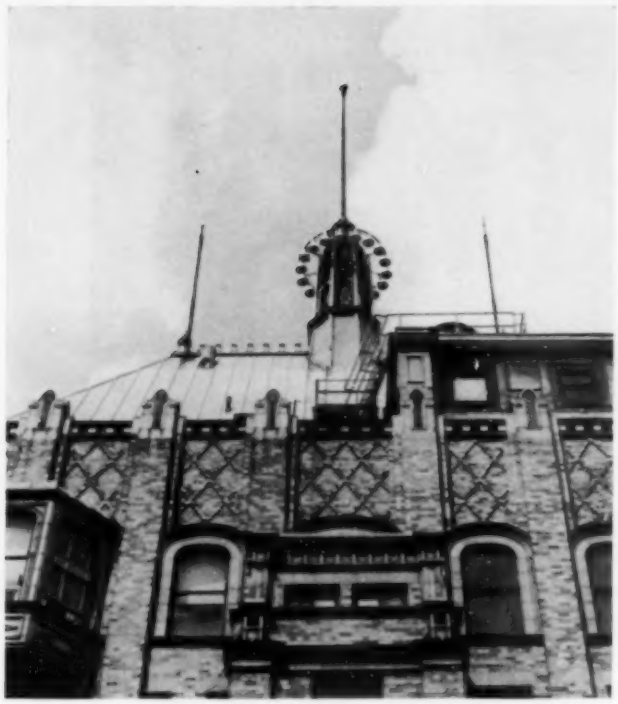
American United Life (Continued)

complished with PAR38 units mounted on rigid rustproof conduit and anchored with clips to the stone work. Forty-four of these units are used to light the entrance, four on each side of four columns and six in each corner (see photo). On the upper porch, seven banks of ten floodlights each are arranged along the floor between the columns and on two sides. The introduction of color, through the use of heat-resistant amber glass lenses over the PAR units, together with the higher lighting levels, effectively displays these two architectural highlights of the building.

In addition to fulfilling all objectives set by the company management, floodlighting provided one added benefit. Reflections from the lighting enable the watchman to move about the building without the use of interior lighting and prevent outsiders from observing his movements within.

Don Meador, Indianapolis Power & Light Co., was the designer of this installation.

Close-up of end column lighting (six PAR38 units) for entrance portico of American United Life building. Four units are used on each side of the four central columns.

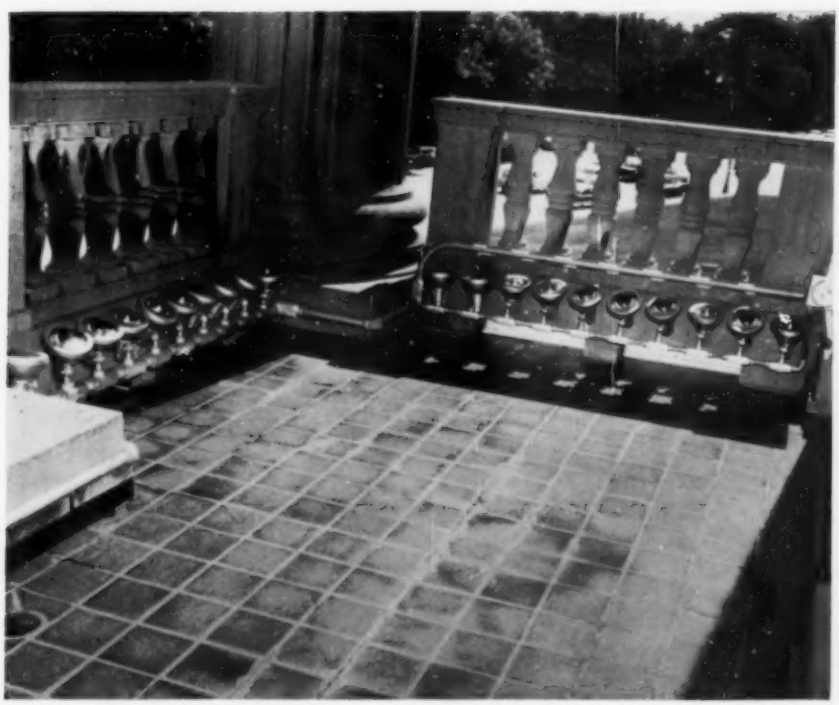


Daylight view of Telephone Co. building tower. Note brick walls, oxidized copper roof, glass-walled turret and flagpole, each requiring individual floodlighting.

area for maintenance of the mercury units on the ring above the turret. The flagpole, which usually flies the company emblem but is also used to signalize the openings of various charity drives, with appropriate flags, is floodlighted by four 500-watt PAR64 lamps in weatherproof units mounted at the parapet below the minarets.

The 71-kw lighting load is balanced on three-phase, four-wire circuits and feeder from the main service in the building's basement. A time clock which actuates a contactor turns the lighting on at dusk, off at midnight. The final effect of the tower, delineated against the nighttime sky and lighted to recall the daytime relationship of the various component parts, has stimulated floodlighting plans for other downtown buildings, perhaps the beginning of one city's consciousness of the value of architectural floodlighting.

Lighting was designed by E. H. Schaefer, Wisconsin Electric Power Co., Milwaukee.



Close-up of floodlight mounting on upper portico of American United Life Insurance Co. building. PAR38 units mounted on rigid, rustproof conduit, and anchored to stone by clips are installed between columns at front and sides of the portico.

Multi-Purpose Recreation Room

Adult Section

Children's Section

Detail of Window Lighting

THE ABUNDANCE of lighting effects used to transform a basement into this pleasant recreation room is a sure sign of the owner's (James Jensen, General Electric Co., Nela Park) profession. No shoemaker's child he! While such an extensive installation might be relatively uncommon, it *does* demonstrate a very effective use of lighting to achieve flexibility of environment for a variety of activities and offers ideas which are well worth adapting to other homes.

The 10½- by 30-foot basement, typical of those found in older homes, had cement block walls, open joists eight feet above the floor and two small high windows at each end. In the remodeled family recreation center, children's play area at one end of the room is separated from the adult section at the other end by a circular game table. To reinforce the division, the random patterns of surface mounted R20 downlights at the two ends are separated by six recessed fluorescent panels over the game table. These are fluorescent strips recessed in a white cavity between joists and covered with white figured plastic diffusers.

A cornice with seven F40 warm white deluxe lamps along one wall provides background illumination and highlighting for travel posters which decorate the cement block wall. In the children's playroom, a pegboard wall used for the display of pictures, souvenirs, maps, etc. is floodlighted by four adjustable bullet units housing 40-watt incandescent lamps. A six-foot T8 slimline lamp in a showcase reflector provides 75 footcandles on the desk. General illumination in the adult area is supplemented by a hanging lamp which provides reading light at a furniture grouping.

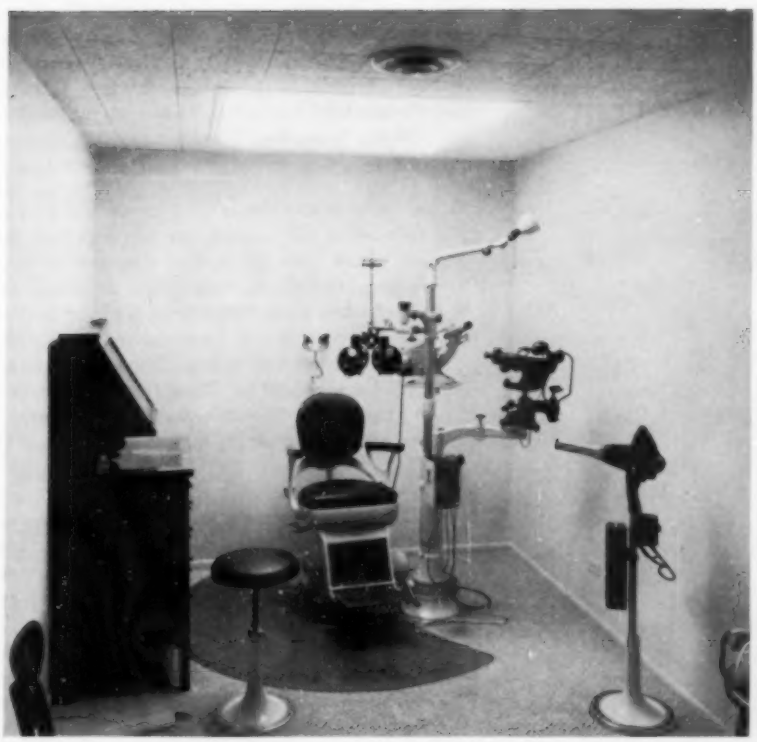
All lighting systems in the room are separately switched and dimmer controlled for maximum flexibility. General lighting level in the children's section is 10 footcandles. At the game table, 30 footcandles are available when all room lighting is in use; 20 footcandles are provided by the fluorescent panels alone.

The basement windows, screened from outside view by sliding plastic panels and lighted from behind by 25-watt showcase incandescent lamps, are a cheerful source of light at any hour.

PARTNERS IN VISUAL COMFORT

Since the optometrist shares with the illuminating engineer, the responsibility for visual comfort and health, he should be a proponent of good lighting—particularly in his own working quarters. IES literature does not contain many specific recommendations for optometrists' offices, but the general quality principles of good diffusion and comfortable brightness ratios are extremely important here. Recommended minimum illumination level for eye examinations is 50 footcandles, but variable lighting levels are necessary to facilitate the examination procedure. An interesting application of dimming, in one of the offices shown here, permits the doctor to prescribe glasses under conditions similar to those in the patient's own working environment.

Installation for Dr. James E. Worden's office in Pomona, Calif. was designed by James E. Kennedy, Southern California Edison Co. Charles W. McQuiston, Philadelphia Electric Co., was the engineer for the lighting of Dr. Elmer S. Friedberg's office in Pottstown, Pa.



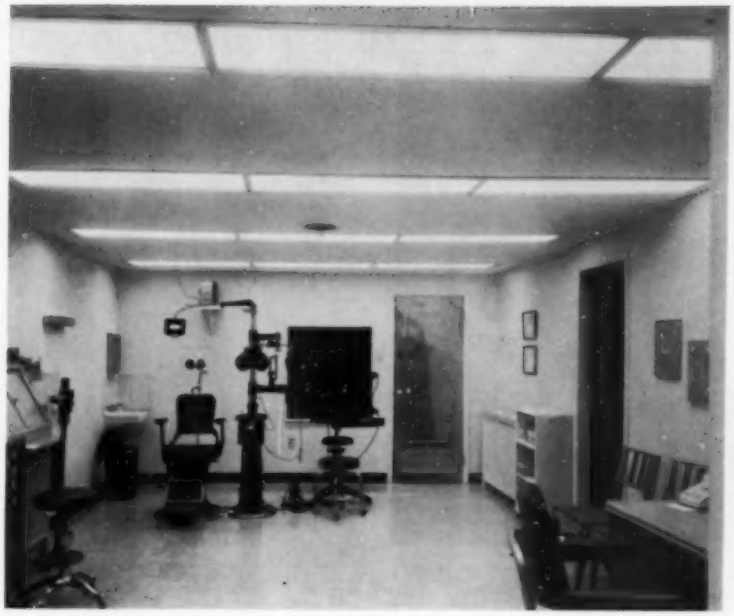
Office of Dr. James L. Worden Pomona, California

Quality lighting in Dr. Worden's offices is achieved through the use of translucent white Plexiglas luminaires and high reflectance surfaces. All rooms except the laboratory have ceiling reflectance of 70 per cent; walls, 65 per cent and floors, 35 per cent. In the 8- by 17-foot examination area shown at left, a four-foot square unit equipped with six 48T12 rapid-start standard warm white lamps is recessed directly above the patient's chair. A dimmer control, conveniently located three feet above the floor near the examination chair, permits the doctor to vary the lighting level between 6 and 105 footcandles at the point of examination. Average illumination level in the room after 125 hours of operation was 59 footcandles.

Shadowless, glare-free illumination in 9- by 14-foot laboratory (above left) used for lens grinding and repairs is obtained from a single eight-foot surface-mounted unit and high reflectance matte finishes on walls and cabinet doors. Walls are ivory, 73 per cent RF; ceiling, off-white acoustic tile, 70 per cent RF; floors, imitation marble, 35 per cent RF. Fixture is equipped with eight 48T12 standard warm white lamps and provided 88 fc after 125 hours. Average brightnesses (similar throughout the doctor's quarters) are: walls, 38 fL; ceiling, 16 fL; floor, 20 fL; bench tops, 19 fL.

Fitting room (above right) is 17 by 43 feet with a nine-foot ceiling and contains five-foot high walnut-finished booths. Six luminaires mounted on approximately eight-foot centers are arranged to provide effective illumination in each fitting booth. Luminaires are eight feet long and equipped with six 48T12 warm white lamps. Illumination level after 125 hours was 60 fc. Three twin wall bracket swivel fixtures with 75-watt reflector lamps provide 95 fc of highlighting on the wall display of frames.

Visual training room (left) identical in size to laboratory is lighted by a single eight-foot surface mounted unit to a level of 82 fc. Other areas similarly lighted include contact lens room where patients are taught to insert and remove lenses, 62 fc; private offices, 74 fc; secretary's office, 72 fc. Since office work performed here does not involve prolonged or difficult seeing, these levels were judged adequate.



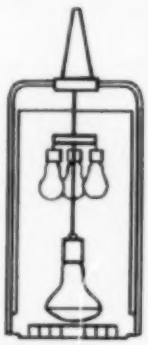
Office of Dr. Elmer S. Friedberg Pottstown, Pennsylvania

Lighting in main examination room and office area, shown here at highest level, is controlled by an 1800-watt rheostat to provide a range of 8 to 140 footcandles. Since the doctor's practice is composed mainly of employees from local industrial plants, the variable lighting levels permit him to fit glasses under "in-plant" lighting conditions, thus improving worker efficiency and productivity. Four rows of two-lamp 48-inch recessed troffers arranged three per row on five-foot centers are used in the examination area; two units are mounted in a narrower office area at one end of the room (not visible). Shielding is from ½- by ½- by ½-inch plastic louvers.

Men's fitting room and foyer is equipped with four two-lamp, 48-inch, surface-mounted fluorescent fixtures on six-foot centers for an illumination level of 55 fc on the fitting table and an average of 50 fc in the room. Two 150-watt R40 adjustable incandescent fixtures directed on the display shelves produce 75 fc. Surface reflectances (identical in all rooms) are walls, 82 per cent; ceiling 87 per cent; floors, 52 per cent.

Three surface-mounted fixtures each equipped with two 48-inch rapid-start deluxe cool white lamps (standard throughout office) are mounted on six-foot centers in a small examination room. The fluorescent lighting produces an average of 50 fc in the room, but supplementary illumination from an incandescent unit mounted on the examination chair provides 75 fc at the examination point.

Section through pendant luminaire.



INSTALLATION AT CLIFTON METHODIST CHURCH, WASHINGTON AVE. AND SPRINGFIELD RD., CLIFTON HEIGHTS, PA.

Lighting a Church

LIGHTING OBJECTIVE: To provide general, well-diffused illumination for reading hymns and for prayers and to create a pleasing atmosphere in a small church.

GENERAL INFORMATION: Main worship area and chancel shown above is approximately 61 feet long, 42 feet wide and 18 feet high. Colors and reflectances of major surfaces are:

ceiling	white	80% RF	floor	natural finish oak	34% RF
walls	pale blue	51% RF	carpet	deep red	10% RF
dado	natural finish oak	32% RF	pews	natural finish oak	32% RF

INSTALLATION: A general level of illumination of 25 footcandles initial is provided by eight NL Corp. catalog No. 6191 pendant luminaires suspended approximately 11 feet above the floor on 13-foot, 6-inch by 20-foot centers. Each lantern consists of an opal glass cylinder diffuser and a hinged louver bottom and is equipped with three 100-watt A-21 inside frosted incandescent lamps and one 500-watt R-40 reflector flood lamp, as shown in the drawing above.

Supplementary lighting for the chancel is from two NL Corp. catalog No. 1487 recessed adjustable downlights on 11-foot centers. Each unit is equipped with one 150-watt PAR-38 side prong lamp. Silhouette lighting of the cross, built of "U" channel members, is provided by 7-watt C-7 white incandescent lamps installed on six-inch centers in the channels.

Brightnesses of the major interior church surfaces were: ceiling, 7 fL; walls, 8 fL; floor, 9 fL; carpet, 3 fL; pews, 9 fL.

Lighting designed by E. F. Kingsmore, retired, Philadelphia Electric Co., Philadelphia, Pa.

Lighting data submitted by Richard F. Flood and George T. Anderson, Jr., Philadelphia Electric Co., Philadelphia, Pa. as an illustration of good lighting practice and to aid in the design of similar installations.

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Developments in Quartz Infrared Lamps

By WILLIAM F. HODGE

Use of the quartz infrared lamp has expanded very rapidly since its introduction in 1954. At present, there are translucent quartz types to cover general purpose uses. Special clear quartz lamps with small diameter filaments serve as line sources for use in office copying machines. Clear quartz lamps operated far above normal loadings are used to test materials, structural parts, models, or whole structures related to aircraft, missiles, and space vehicles. For particular operating conditions several special varieties are available. These include lamps for universal burning position, lamps designed for very high wattage, lamps with platinum outer leads for intermittent operation where seal temperature is very high, and lamps with the ends bent at right angles to isolate the seals from hot zones in ovens or closely spaced arrays.

Use of the quartz infrared lamp has expanded very rapidly since its introduction in 1954. A 1955 IES Conference paper showed eight varieties; now there are over forty. A few of these are shown in Fig. 1. Applications fall into three broad categories. The lamps in these categories differ considerably in construction, but even more in operating conditions.

General Purpose Lamps—For Heating Things and People

The more conventional applications constitute the first category. Fig. 2 shows an infrared lamp oven that is used to bake the paint on automobile license plates. Fig. 3 illustrates an installation of one hundred and twenty-three lamps above the show windows of the Carson, Pirie, and Scott Department Store in Chicago, typical of some of the most recent installations.

Lamps used for these applications are made of translucent quartz and operate at 100 watts per inch with a 2500K color temperature. In addition to the original 500-, 1000-, and 2500-watt lamps, 500-watt, 104-volt and 1000-watt, 208-volt lamps are now available for low line voltage conditions sometimes encountered in grounded neutral 120-240-volt systems, as well as 208-volt systems. Further, 375-watt 120-volt, 1600-watt 240-volt, 2500-watt 600-volt, and 3800-watt 570-volt lamps have been added. The 3800-watt lamp has sometimes been utilized on 480-volt lines at approximately 3000 watts.

Vertical Burning Lamps for Increased Versatility

Horizontal operation was originally specified for all types. This was based on tests involving 1000-watt and 2500-watt lamps. In 1000-watt and longer lamps, the weight of the tungsten filament is great enough so that it stretches in vertical operation. This results in bowing or buckling of the lower part of the filament, which eventually contacts the quartz, causing devitrification and failure. It has since been found that the 500-watt lamp is capable of operating vertically. Special versions of the 1600-watt and 3800-watt lamps are also made for operation in positions other than the horizontal. Fig. 4 shows the structure of such a lamp. The tantalum metal discs that center the filament in the tube are supported at intervals by diametrically opposite indentations in the tube wall. Distances between

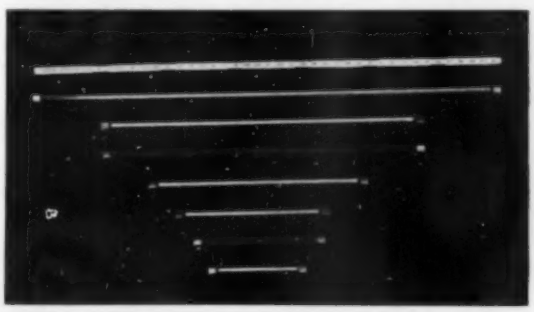


Figure 1. Quartz infrared lamps typical of over forty available types. Those shown here are 500-, 1000-, 1600-, 2500- and 3800-watt translucent, and 1000- and 5000-watt clear quartz varieties.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHOR: General Electric Co., Cleveland, Ohio.

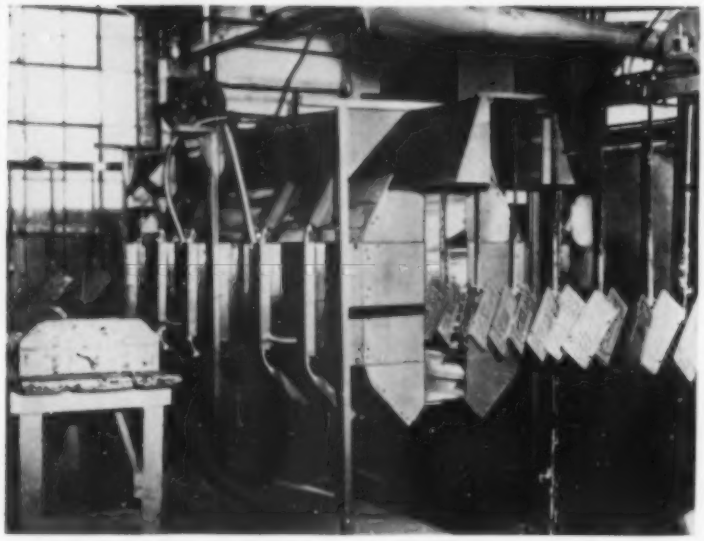


Figure 2. Quartz infrared lamps dry the paint on automobile license plates for the state of Connecticut.

these pairs of indentations are short enough so that no appreciable filament sag takes place. This type of lamp is universal burning; however, one end is marked "This End Up," and must be the upper of the two in installation; otherwise the indentations will be above, rather than below the discs that they are supposed to support. While indentations adjacent to both surfaces of the discs would make this unnecessary, it would cost appreciably more. It should also be noted that in vertical, or close to vertical, operation the upper seal will normally run somewhat hotter than in horizontal operation, so that greater care may be needed to ensure its operating at less than 650F.

Figure 3. One hundred and twenty-three 1000-watt quartz infrared lamps are mounted over the display windows of Carson, Pirie, and Scott's Chicago department store. Idle summer air conditioning power facilities operate the installation.

Design and Application Features

The quartz infrared lamp is a small diameter linear source. Although it is not suited to point source applications, it lends itself admirably to area coverage where rectangular patterns are usually desired. Fixtures such as the one shown in Fig. 5 provide very uniform intensity, can be ventilated satisfactorily, and can be relamped from the front.

Electrical characteristics of existing general-purpose lamps range from about 15 to 24 volts per inch and 2.3 to 6.7 amperes. These characteristics result in filament lengths which are suitable for standard operating voltages, and have been found to be most practical from the standpoint of lamp performance.

Lamps for Office Copying Machines—A Highly Specialized Application

The second category consists of lamps used for office copying machines, such as the one shown in Fig. 6. This is a highly specialized application, generally involving operation of the lamp in an accurately contoured reflector. To obtain a satisfactory linear source for this type of operation, lamps are made of very high quality clear quartz with a heavier, smaller diameter, higher color temperature filament. Filament straightness is of primary importance. Lamps meeting the high precision requirements necessary for this type of application

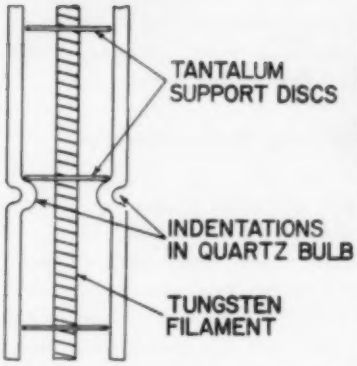


Figure 4. For vertical operation of quartz infrared lamps, indentations in quartz tubing support tantalum discs attached to filament. This keeps filament from stretching due to its own weight, preventing bowing or buckling at lower end.

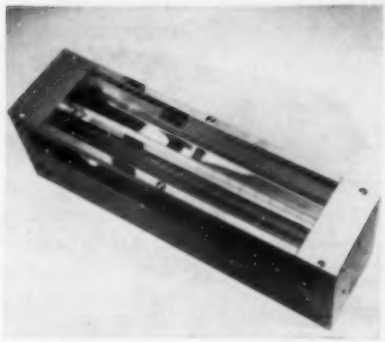


Figure 5. General purpose fixtures which are available in various lengths utilize gold-plated reflectors for maximum efficiency. Separate compartments at the ends promote proper seal cooling to prevent oxidation of the molybdenum in-leads.

Figure 6. Office copying machine, designed for use with heat-sensitive paper, is equipped with precision quartz infrared lamp. Absorption of infrared energy by printed characters results in temperature rise and heat flow to produce image.

are more expensive to manufacture than other types of lamps, and are not generally suited for other purposes.

Lamps for Aircraft, Missile, and Space Vehicle Structure Testing

The great race to see who can be the first to put a man on the moon has given great impetus to this application. It involves heating materials, structural parts, models, or whole structures to simulate conditions encountered in flight. Enormous energy concentrations are required. Time involved is generally short—from a few seconds to a few minutes in most cases. Specimen temperatures, and temperature distributions as well, must be varied rapidly and accurately controlled. This is done by precision programming and control equipment that is preset to vary the specimen temperatures in the same way that the actual missile temperatures would vary as the missile passes through various regions of the earth's atmosphere. The fast heating and cooling and low thermal capacity of quartz infrared lamps make them by far the most satisfactory device for such purposes. A further advantage is the fact that wattage concentration can be increased to extremely high levels by overvoltaging the lamps. Fig. 7 shows 225 lamps in a cylindrical array for heating missile components. Total power may run as high as 2500 kw.

For this type of application, clear quartz lamps are used. Translucent quartz absorbs enough energy to soften with extreme overwattage operation. Clear quartz types available now include 500-, 1000-, 1600-, and 2500-watt varieties with nominal ratings of 100 watts per inch; also 2000-, 3200-, and 5000-watt lamps with nominal ratings of 200 watts per inch. Some versions of these have a minimum dead space length at each end to permit end-to-end mounting with as little gap as possible between filament ends. Nominal ratings are for a filament color temperature of approximately 2500K. Operating characteristics with overvoltage depend on the degree of overvoltage in use, of course; however, twice nominal voltage results in

Figure 7. Cylindrical array of quartz infrared lamps used for testing missile components. The lamps have twenty-five-inch filaments, and are mounted on very closely spaced centers. For short periods, individual lamp wattage may be as high as 15 kw.

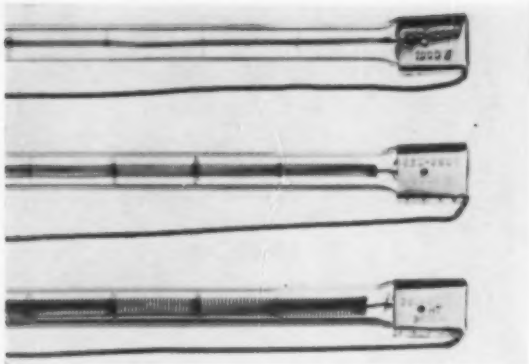


Figure 8. The developmental 360-watt-per-inch filament in the bottom lamp dwarfs the 100- and 200-watt-per-inch filaments in the two lamps above. Although the 360-watt-per-inch lamp has a short life when overvoltaged, it will operate satisfactorily for many hours at the nominal 360 watts per inch.

three times nominal wattage, and this is often used. Life under these conditions is very short.

For very short periods of operation, maximum permissible wattage is determined by the melting point of the tungsten filament. For a 200-watt-per-inch filament, this will be reached at a little over 1000 watts per inch, and generally results in a violent failure, due to arcing. At 1000 watts per inch such a filament will operate satisfactorily for a number of seconds. Tungsten evaporates very rapidly from the filament, however, and will soon blacken the quartz so that it absorbs enough energy to soften. At 600 watts per inch, a single lamp may operate satisfactorily for an hour or more. In actual installations, however, lamps are mounted very close to each other in reflectors. These reflectors generally face each other, or are close to reflecting or radiating surfaces of the specimen. Under these conditions, both the quartz and the molybdenum inlead seal wires may overheat, resulting in quartz softening, or oxidation and disintegration of the seal wire. It is often impossible to predict performance of such an installation except by actual trial.

Maximum Watts Per Inch

Attempts have been made to determine the maximum watts per inch that can be incorporated in a T3 quartz bulb. Fig. 8 shows present nominal 100- and 200-watt-per-inch lamps together with a new developmental 360-watt-per-inch lamp. This appears to be about as high as is practical. At overvoltage, it is capable of operating at as high as 1500 watts per inch for very short periods, and life is determined by what the quartz will stand. This lamp can only be operated for a few seconds at a time, because of this. Increasing the diameter of the quartz bulb would increase necessary lamp center spacing and defeat its purpose.

Effect of Seal Operating Temperature on Lamp Life

The maximum safe operating temperature of the seals of quartz infrared lamps is 650F. If this is exceeded in operation, failure occurs within a short time. Fig. 9 shows a longitudinal cross section of a molybdenum foil seal. This particular seal is the one-piece rolled type that has been found most economical and dependable, but the principles involved apply also to three-piece seals, sometimes used for higher currents and commonly used in quartz mercury vapor lamps of various types. These seals are hermetic only in the center portion where the molybdenum thickness is only about .0007 inch. At the ends, where thicker material is necessary for mechanical strength, contraction of the molybdenum from the 3600F temperature required to soften the quartz and press it against the metal results in an appreciable gap between the molybdenum and the quartz, since the quartz has nearly zero expansion coefficient. Air circulates in this space and, if the temperature is over 650F, will oxidize the molybdenum. Depending upon the particular temperature involved and other operating conditions, the oxidation may eat through the hermetic seal and cause a leak; oxide, which occupies more volume than the metal, may cause the quartz to crack; or in the case of extremely

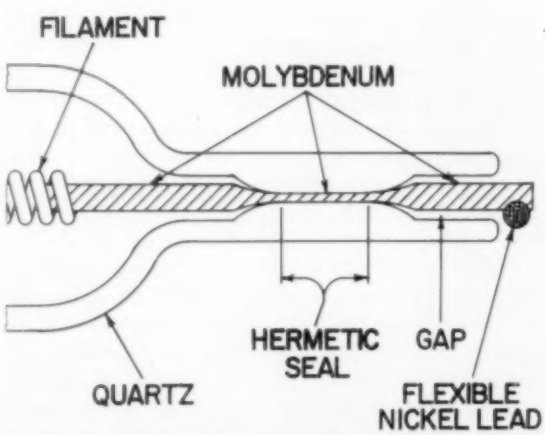


Figure 9. Cross-section of a molybdenum foil seal showing the gap between the molybdenum and the quartz resulting from the greater contraction of the molybdenum with almost no contraction of the quartz after heating to make the seal.

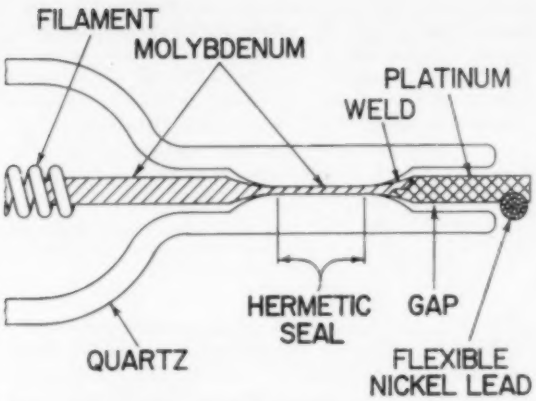


Figure 10. Substitution of platinum for the outer part of the molybdenum lead eliminates rapid oxidation of this part when the seal temperature is as high as 1500F.

high temperatures, the outer part of the lead may disintegrate completely.

Molybdenum is the only material that is satisfactory for the seals in quartz infrared lamps. Although a great deal of work has been done in the field of oxidation resistant coatings for molybdenum, none of it has been applicable to foil leads. If the thin part of the lead is coated, it becomes too thick to seal satisfactorily; moreover, the coatings themselves don't stand the sealing temperature. If the thin part is not coated and the thick part is, there is always a gap between the coating and the hermetic seal end, and oxidation takes place at this gap.

Isolated Seals Help to Prevent Oxidation

Where lamps are mounted in arrays, particularly in oven or furnace types of configurations, seal temperatures often tend to exceed 650F, so that it is necessary to provide some means of cooling or isolating the seals from radiant heat. For this reason, the general purpose translucent quartz infrared lamps (and some of the clear quartz varieties) are made with an inch of dead space between the end of the filament and the seal, making it possible to extend the lamp end into an enclosure that is cooled by convection or forced draft. The fixture of Fig. 5 has a compartment at each end to house the seal. By using a blower, air can be forced through these end compartments in installations involving a number of lamps. For widely spaced, smaller numbers of fixtures, convection cooling is sufficient. It is worth while to observe that some installations have shown a considerable variation in seal temperature in different fixtures or fixture ends. This indicates the need to make an adequate number of temperature measurements to determine conditions accurately.

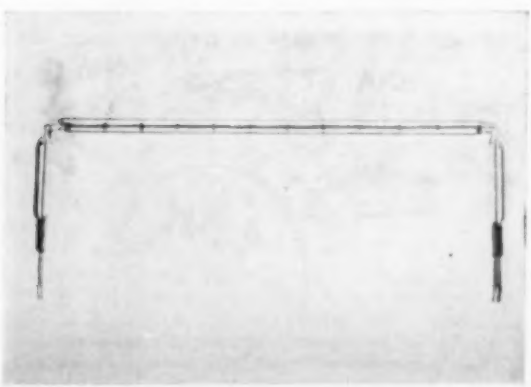


Figure 11. Long dead ends bent at right angles to the axis of the lamp proper allow location of the seals behind the reflector to keep them cool.

Platinum Leads Increase Life at Extreme Temperatures

Although no protective coating has been devised that will prevent seal oxidation over a long period of time, a means of protection that is effective for certain types of operating conditions is available. This consists of substituting a length of platinum wire for the outer part of the lead. Fig. 10 shows how this is done. This seal will last for 100 hours or more at very high temperatures; for example, 1500F. Unfortunately, the use of platinum gives no increase in life at lower temperatures that exceed 650F. This restricts the use of platinum lead lamps mainly to the field of aircraft and missile structure testing. It is of great value here, however, since seal temperatures as high as 1500F sometimes occur in multiple lamp arrays operating at high overwattage. At such temperatures the outer lead of the standard seal oxidizes and disintegrates due to the rapid circulation of very hot air. Air doesn't penetrate rapidly through the small gap between the platinum wire and the quartz that leads to the molybdenum part, so the molybdenum has a relatively long life.

The Bent End Lamp—A Logical Solution to the Seal Oxidation Problem

Another answer to the problem of seal oxidation has been found in a lamp which has the ends bent at right angles to the axis. This lamp is shown in Fig. 11. The long right angle dead ends make it possible to put the seals on the back side of the reflector surface, removing them entirely from the

hot zone. A special type of terminal which is used on this lamp allows rigid connections to electrical terminal blocks with sufficient longitudinal flexibility to take care of dimensional tolerances and fixture expansion.

Although the cost of this type of lamp is appreciably higher, increased life and simplification of the problem of cooling the seals may much more than offset the added cost. The construction is, of course, applicable to lamps made of either clear or translucent quartz.

A Great Future

The 1955 paper by Christensen and Foote predicted a great future for quartz infrared lamps. This prediction was correct, as there are more than five times as many lamp types now, and an untold number of applications. Interest in these lamps continues at a high level, and further progress in design and application seems assured.

Reference

1. Christensen, M. and Foote, A. G.: "Development and Application of Quartz Infrared Lamps," ILLUMINATING ENGINEERING, Vol. LI, No. 5, p. 377 (May 1956).

DISCUSSION

W. E. THOURET:* The improvements in existing quartz infrared lamps and the development of an impressive number of new types, as described by Mr. Hodge, are extremely interesting. The techniques of manufacturing lamps of fused quartz tubing with quartz-to-metal seals were originally developed for mercury arc tubes. It is particularly noteworthy that they now find increasing application in the field of incandescent filament sources.

Mr. Hodge describes the limitations of molybdenum foil seals caused by oxidation of the foil end at temperatures which exceed 650°F. This effect is well-known to those who are familiar with the design problems involved in mercury quartz tubes and related discharge lamps. With certain high pressure lamp types which are operated without outer bulbs, the experience has been that graded glass tungsten wire seals can be made less sensitive to oxidation than molybdenum foil seals. In some instances, such graded glass seals are used in addition to molybdenum foil seals for the purpose of protecting the latter against oxidation. I would like to ask whether graded glass tungsten wire seals have been considered or investigated for use in quartz infrared lamps and, if this is the case, what results have been obtained?

My other question refers to Mr. Hodge's description of the problems encountered with high wattage concentration lamps. He states that with overwattage operation evaporated tungsten from the filament will soon blacken the quartz so that it absorbs enough energy to soften. I would like to ask whether the iodine cycle described by Zubler and Mosby in their paper presented at the 1959 IES Conference[1] could not be used to prevent blackening of the quartz. Zubler and Mosby state that their remarkable development of the iodine incandescent lamp with nearly perfect maintenance was initiated in connection with development work on quartz heat lamps. Dimensions and characteristics of the quartz heat lamps seem to be very similar to those required for proper functioning of the iodine cycle. Therefore, it seems to be of interest to learn what particular reasons have prevented the use of the iodine cycle in infrared heat lamps of the described design.

*Duro-Test Corp., North Bergen, N. J.

1. Zubler, E. G. and Mosby, F. A.: "An Iodine Incandescent Lamp with Virtually 100 Per Cent Lumen Maintenance," ILLUMINATING ENGINEERING, Vol. LIV, p. 734 (December 1959).

H. D. FRASER:* In regard to severe overloading for special applications, the paper mentions that translucent quartz cannot withstand 1000-watts-per-inch loading. This raises a question as to what loading translucent quartz will stand. Perhaps in answering this, the author will describe his experience in comparing loading limits with quartz made by different processes.

WILFRID G. MATHESON:** The author has recounted several design changes and lamp applications which have been successfully accomplished in the past few years. The unique ability of these lamps to perform under heavily loaded conditions should lead to further use in even more exacting conditions.

The use of platinum as an outer-lead material does provide for high temperature seal operation; however, a less expensive method is greatly to be desired. The introduction of cool and bent ends is a very important feature for the protection of both the lamp seal and socket.

The design for vertical burning fulfills a need where application in other than the horizontal position is desirable.

J. R. FAVORITE:† Mr. Hodge mentions that one of the applications of the quartz infrared lamp is for office copying machines or, rather, thermographic office copying machines, and discusses some specific requirements of the lamps used for this purpose. I should like to briefly describe the thermographic copying process and elaborate on these requirements.

Fig. A shows schematically the cross section arrangements of lamp, reflector, copy paper, and original for mak-

*Westinghouse Electric Corp., Bloomfield, N. J.
**Sylvania Lighting Products Inc., Salem, Mass.
†Minnesota Mining and Manufacturing Co., St. Paul, Minn.

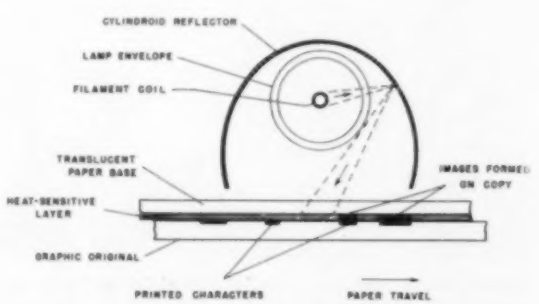


Figure A (Favorite discussion).

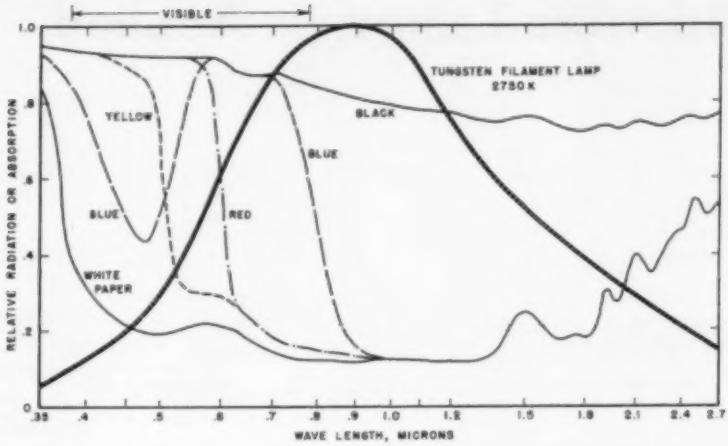


Figure B (Favorite discussion).

ing a copy by this process. A heat-sensitive copy paper is placed over a graphic original and carried over the front of the lamp and reflector combination. Uniform, intense radiation is concentrated within a narrow band on the copy paper. Upon absorption of the intense radiation by the printed characters, its temperature rises and subsequently the heat pattern corresponding to the image structure is conducted to the heat-sensitive copy paper. A rapid chemical reaction takes place and image formation results.

In photography, energy transfer for image formation results from absorption of radiant energy by the light-sensitive copy paper. The direction of flow of radiant energy is independent of time. Therefore, image definition is unaffected by increased exposure time, provided the exposure is sufficient.

In thermography, on the other hand, energy transfer for image formation results from the conduction of heat energy to the copy paper from the original after absorption of radiant energy by the original. A reduction of the time duration for heat conduction will produce an image whose structure conforms more closely to the shape of the original. To complete image formation with reduced exposure time, it is necessary to have a high imagewise temperature gradient, and hence a high concentration of radiant energy. Even though the highest possible concentration of radiant energy can be approached by focusing in the form of a line on the copy paper the original combination using a cylindroid reflector and a line source, an actual energy source is cylindrical with a finite filament coil diameter to provide sufficient surface area for adequate energy emission. The filament coil diameter must be as small as possible. A lamp intended for thermographic reproduction, therefore, must have a small, straight filament coil, capable of high wattage dissipation, with a clear, straight, and small diameter quartz envelope.

Mr. Hodge also mentions the desirability of high color temperature. Present infrared lamps emit mainly in the infrared. Fig. B shows the relative radiant power vs. wave length of an infrared lamp at 2750°K color temperature and spectral absorption characteristics of some typical colorants. The spectral radiation curve of the lamp overlaps for a wide spectral range with the absorption curve of carbon black and only barely with the other colorants; hence, colors are not copied very well by the thermographic copying process using infrared lamps. To improve the color copying ability, we would like to see the radiation from the lamp shifted toward the visible region without reducing total output.

We welcome any improvements in lamp characteristics for the greatest possible concentration of uniform radiation within a narrow band and any possible means of shifting the radiation to the visible region.

WILLIAM F. HODGE:* In answer to Dr. Thouret's first question, it would be possible to make quartz infrared lamps with graded glass tungsten wire seals, and this has been done in the laboratory. The foil seal, however, is much less expensive. Furthermore, it is immune to thermal shock, resulting in a less costly and much more reliable structure.

Theoretically, the resistance of tungsten to oxidation is greater than that of molybdenum. Practically, however, the increase in lamp life achieved when tungsten is used is not appreciable.

The combination of a graded glass seal at the outer extremity of the lamp, and an inner foil seal, is a mercury lamp technique, used where the function of the inner seal is to confine the mercury vapor to the warmer parts of the lamp in order to prevent its condensation. In quartz infrared lamp operation, seal temperature and, therefore, lamp life, is affected partly by the length of the dead space between the seal and the end of the filament; it is also affected, to a large extent, by the proximity of other lamps in an array.

Use of the iodine cycle, as described by Zubler and Mosby, would be applicable to some of the high wattage infrared lamp uses. The lamp is inherently more expensive, but the expense may be justifiable in some cases.

To answer Mr. Fraser's question on the watts-per-inch loading limit for translucent quartz T-3 lamps, very little has been done with translucent quartz in the missile structure test field. In a particular case that has become ancient history, 250 watts per inch were found to be excessive. In any case, it is difficult to put figures on these limits, since operating conditions involve so many other variables.

As Mr. Matheson states, an inexpensive method of protecting seals from oxidation would be very desirable.

Mr. Favorite has very nicely clarified the details of the thermographic copying process.

*Author.

Aperture Lamps . . . Applied

By S. C. PEEK

A new fluorescent lamp has been developed for the primary purpose of providing a narrow, brighter source and a luminaire designed to take advantage of these lamp characteristics. This paper shows why brightness and narrow width are important in a fluorescent source, describes an integrated system and shows the results in various applications.

Theory

The illumination, E_p at a point, P of remote distance, D from a circular source of uniform brightness, B is commonly calculated in terms of the source beam candlepower, I.

$$\text{Thus, } E_p = \frac{I}{D^2} \qquad (1)$$

This can be shown to be equivalent to the brightness of the source multiplied by the solid angle, ω subtended by the source as viewed from point P divided by π.

$$\text{Or, } E_p = \frac{B\omega}{\pi} \qquad (2)$$

In fact, Equation (2) is more fundamental than Equation (1) for the latter is accurate even though D is not large compared to the diameter of the source while Equation (1) becomes decreasingly accurate as D approaches the source diameter.[1]

The same argument applies for sources of other than circular shape. The equations become more complicated, but illumination is always proportional to brightness. If a specular reflector is filled with an image of the source, it becomes a new source which takes on the dimensions of the flashed portion of the reflector. The brightness of the new source equals the source brightntess times the reflectivity of the reflector.

$$B_r = \rho B$$

Since the size of reflectors is normally limited by practical considerations, high brightness of the source is a fundamental requirement in obtaining high illumination at a remote point from a luminaire. High brightness of the source also enables one to reduce the dimensions of the source allowing a better opportunity for control of the light with small reflectors.

The introduction of aperture fluorescent lamps[2] make available linear light sources of smaller and brighter characteristics than were previously available in fluorescent lamps. When these lamps are used with a half parabola reflector the following characteristics can be simultaneously obtained:

(1) High illumination at a remote point,
(2) Low power consumption,
(3) Sharp cut-off in the vertical distribution,
(4) Narrow vertical distribution,
(5) Small luminaire size,
(6) Wide lateral distribution (automatically results from long linear systems).

Although many other systems have several of the above characteristics, the new lamps and reflectors make possible the accomplishment of all the above features simultaneously.

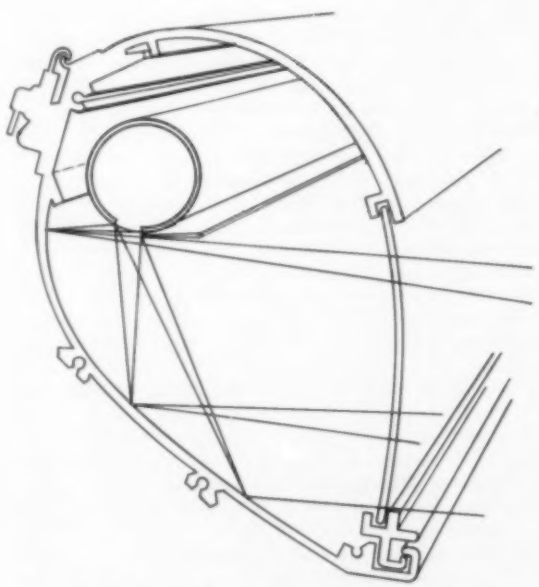


Figure 1. Cross-section of the aperture lamp luminaire with light shield.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHOR: Sylvania Lighting Products, Salem, Mass.

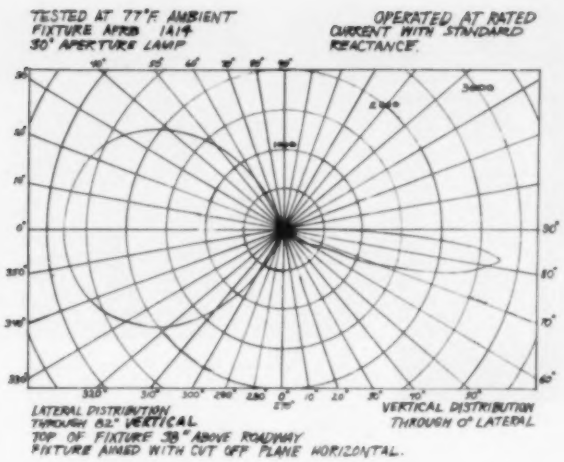


Figure 2. Candlepower distribution for the aperture lamp luminaire.

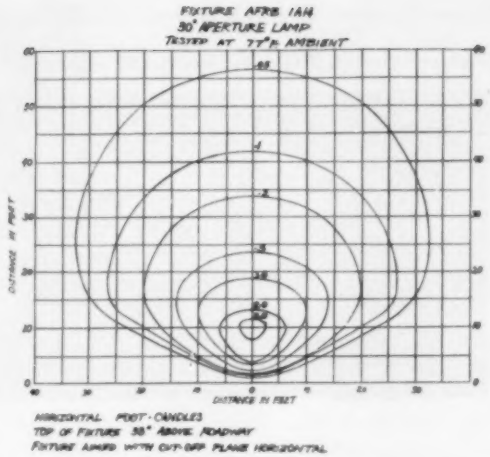


Figure 3. Isolux for aperture lamp luminaire at 38-inch mounting height.

Luminaire Description

The luminaire which can use, without modification, either a 30-degree or 60-degree aperture lamp is shown in cross-section in Fig. 1. The forward edge of the aperture is at the focal point of the parabolic reflector so that most of the light emanating from the aperture is below the cut-off plane. The small amount of light emanating from the not quite opaque reflectorized portion of the lamp would normally produce some light above the cut-off plane. This can be prevented by use of the optional light shield shown in Fig. 1.

Fig. 2 is the candlepower distribution curve for the 30-degree lamp in the luminaire with a light shield. The use of the 60-degree lamp provides somewhat less maximum candlepower, but results in a wider vertical distribution. Fig. 3 is an isolux chart of horizontal footcandles for a 38-inch mounting height. The brightness of the reflector is less than 300 footlamberts as viewed above the cut-off plane, while the brightness in the beam is 13,000 footlamberts.

General Areas of Application

The general characteristics outlined in the first section of this paper lead to some interesting practical results when the luminaire is properly applied. Generally, the system is best suited to lighting long, relatively narrow areas, such as roadways, runways, building fronts, etc. These applications take advantage of the wide lateral distribution.

When the luminaires are mounted in a line near the edge of such an area, each unit contributes to the illumination in front of adjacent units, which also tends toward more uniform lighting. The high beam candlepower and narrow vertical distribution enables one to obtain more nearly even illumination at remote and nearby points, even though the luminaire is mounted close to the surface to be illuminated. The sharp vertical cut-off greatly reduces the glare. If the fixture is mounted under eye-level and aimed horizontally, one will never look into the main beam. In high-mounted installations it is always possible for one to look into the main beam at some point close to the luminaires regardless of the cut-off angle.

Applications to be discussed can be divided into four classes: Class I—Low Mounted; Class II—Medium Mounting Height (three to fifteen feet); Class III—Vertical Surface Lighting; Class IV—Uses Needing No External Reflector.

Applications

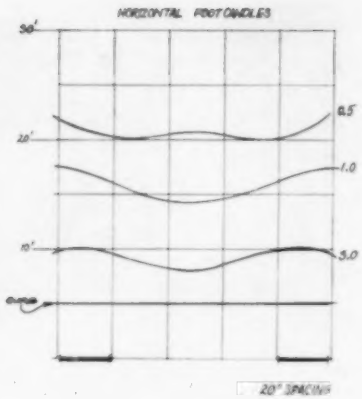
Class I—Low Mounted

Fig. 4 shows a section of the New Jersey Turnpike illuminated by 40 aperture lamp luminaires with 30-degree lamps mounted 38 inches high and

Figure 4. New Jersey Turnpike lighted by 40 fixtures.

Figure 5 (below). Turn-off at Route 128 illuminated by 30 luminaires.

Figure 6 (right). Isolux for Route 128 as shown in Fig. 5.



spaced, alternately, 10 feet and 30 feet apart. Fig. 5 shows a section of an approach on Route 128 in Peabody, Mass. lighted by 10 luminaires, and an adjacent turn-off lighted from the opposite side by an equal number. The spacing between units was 10 feet; mounting height was 38 inches with the cut-off plane adjusted horizontally. Thirty-degree lamps were used here. Fig. 6 is an isolux of horizontal footcandles measured on this installation.

The luminaire has been designed into a continuous rail, Fig. 7, which is suited for bridge lighting. Vibration problems of poles have been eliminated and the excellent uniformity resulting from a continuous strip of illuminating source has encouraged interest in this system for bridge lighting.

Greater illumination at the center of runways is possible through the higher brightness of the aperture lamp system. Runways are much wider than roadways and, therefore, require larger reflectors in order to obtain equivalent uniformity.

No claim is being made that this system is immediately applicable to headlights on passenger vehicles, but it has been tried experimentally. The wide horizontal distribution was found to aid in dynamic vision. One can gain a much better conception of one's dynamic visual environment with the broad and even illumination from the aperture lamp system than one can from the narrower, but higher candlepower, of the incandescent system. The candlepower down the center of the road is higher than the standard low beam, but is less at the right-hand edge of the road. The light shield was not used because sharp vertical cut-off is not desired in the United States. Work is continuing on this application for it is expected that some linear headlight will gain acceptance in the future.

Class II—Medium Mounting Height (Three to Fifteen Feet)

Fig. 8 shows the rear of a trailer being illuminated by the system. The sharp vertical cut-off can be observed on the wall and trailer door. This enables the driver to back into position with little glare, but still provides good illumination inside the trailer.

The wide horizontal distribution coupled with sharp cut-off produced an interesting method of lighting marinas as shown in Fig. 9. An installation was made at Perkin's Marina in Essex, Mass. in order to discourage pilfering. Very little glare in the eyes of the operators of approaching boats was observed.

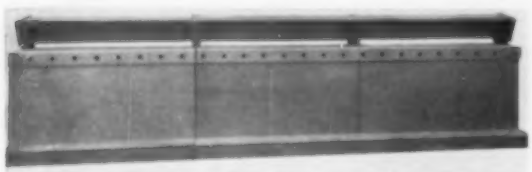


Figure 7. Continuous rail design for bridges.

Figure 8. Truck-loading ramp illuminated by an aperture lamp luminaire.

Figure 9. Marina illuminated by one fixture.

Class III—Vertical Surface Lighting

It is usually desirable, for architectural reasons, to mount luminaires for lighting building fronts close to the surface to be illuminated. Fig. 10 shows such an installation. Although there is more illumination toward the top of the building front than at the bottom, the uniformity is quite surprising for a mounting distance of only 18 inches from the building front surface.

Class IV—Uses Needing No External Reflector

Since only a narrow light source is needed to light plastic edge-lighted signs, the aperture lamp is well-suited to this application without any need for an auxiliary reflector or optical system. The brightness of the letters is in direct proportion to the brightness of the lamp and, therefore, brighter edge-lighted signs are possible. Fig. 11 shows such a sign demonstrated on Route 128 in Peabody, Mass.

Conclusion

The aperture lamp and associated luminaire were conceived as an integrated system to fill a need for greater throw and vertical control in fluorescent lighting. The concept of brightness and solid angle instead of beam candlepower encourages clearer understanding of this system and has led to the use of the system in a wide range of applications.

References

1. Spencer, D. E. and Montgomery, L. L.: "Interflections in Aperture Lamps," a paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa.

2. Toomey, C. L.: "Design and Characteristics of Aperture Fluorescent Lamps," a paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa.

Figure 10. Facade lighting of a building front.

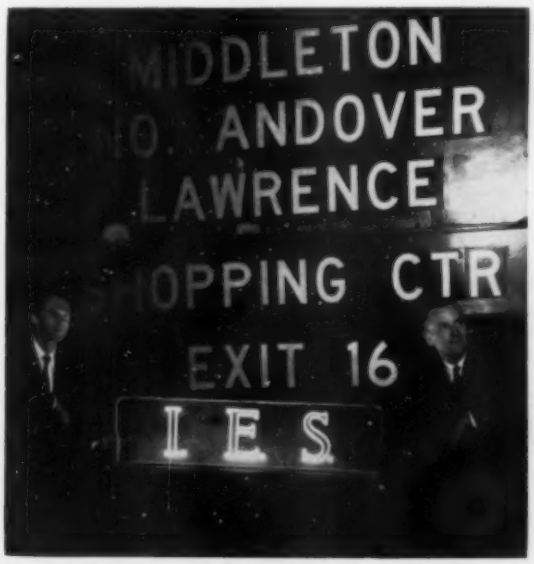


Figure 11. Edge-lighted plastic sign with bare lamp.

DISCUSSION

CHARLES REX:* We have also investigated the use of aperture fluorescent lamps for roadway lighting. Low-mounting-height luminaires may be modified in size and other design features by using aperture lamps.

Whether these aperture lamps or standard lamps are used to accomplish a specified performance often depends upon over-all annual cost as well as other considerations, such as compact size, mountings, etc. Over-all annual cost includes user stocking and handling of special lamps, maintenance replacement of lamps in proper orientation, cleaning, etc.

Generally good design, to accomplish desired performance, involves the least practicable confinement of light in the source and the luminaire. The paper shows the user the control that is attainable by means of one design approach. User knowledge of possibilities often has considerable merit in advancing lighting progress.

I assume that the 300 fL reflector brightness above the cutoff plane was measured directly facing the unit rather than at representative distances ahead of the driver.

D. M. FINCH:** This is a timely paper which points up some developing techniques that will have important applications in several fields. The use of linear sources of small cross section and high brightness is intriguing for several applications. Before commenting on these potential applications, I would like to make several suggestions regarding the material presented in the paper.

The author might wish to review Equations 1 and 2. To be correct, in Equation 1, E_p should be defined as the illumination in a plane perpendicular to direction, D. In Equation 2, E_p should still be defined as the normal illumination (perpendicular to direction, D) and the equation is only applicable if the solid angle, ω, is small. Therefore the comment that "Equation 2 is accurate even though D is not large compared to the diameter of the source" is not correct. The equation for the illumination from a large source of uniform brightness, B (in footlamberts), should be,

$$E_p = \frac{B}{\pi} \int_{\omega} d\omega \cos\theta$$

where: $d\omega$ is the differential solid angle from each portion of the source to the point, P.
θ is the angle between the direction P—$d\omega$ and the normal at P.

The low-mounted applications are particularly interesting to me. The general statements made in the paper regarding these applications have been checked and verified by me in calculations and field tests. I have come to the conclusion that for special applications on roadways, low-mounted units offer distinct advantages over conventional high-mounted units. The special applications that I refer to are: (1) bridges; (2) structures in roadways such as interchanges; (3) turn-on and turn-off ramps; (4) controlled access roadways with fences, guard rails or crash barriers already installed along the edges or in the median. In such cases the basic mounting structure is already available, so the cost of installation is favorable.

There are several other advantages to low-mounting that have not been emphasized in the paper. Many times the directional reflectance properties of roadway surfaces are more favorable for low-mounted units insofar as pavement brightness is concerned. It is usually possible to develop a very uniform pavement brightness in the longitudinal direction. The narrow vertical distribution now possible also improves the transverse brightness distribution.

During rainy weather and in fog low-mounted units have distinct advantages. The freedom from glare that is possible is also an important aspect of this development.

The high vertical surface illumination that results from a system of low-mounted units is very beneficial in revealing objects on the roadway and in developing surface texture.

The esthetic attributes of low-mounted units are sometimes of great importance. It is now possible to light a structure or a roadway without a forest of poles and without glare sources in the field of view.

The fact that this technique is new and developing should be taken into consideration. There will have to be a number of field installations made and experience needs to develop before the best practice can be prescribed.

PHELPS MEAKER AND DAVID A. TOENJES:* All who have worked with light sources and optical systems get a particular thrill out of combinations that produce accurate control of light, whether it be a concentrated beam or fan-shaped spread with close vertical control. Working with this small, bright source and a well-designed reflector must have given the author this kind of satisfaction. We think one can accept the list of six features, even though there may be arguments as to how low is low, how narrow is narrow, and how small is small. We would like to add a seventh feature which seems to be quite exclusive with this luminaire concept: the possibility of producing a fan of colored light at an efficiency hitherto unobtainable.

Since the merit of the aperture lamp in a polished reflector results principally from the narrow (approximately ⅜ inch wide) bright source, we would like to mention results with the new tubular quartz filament lamps. In these the actual source is smaller, and astonishingly high concentrations have been obtained. Experimental reflectors with louvers or a shield have eliminated spilled light to provide the desirable sharp upward cutoff. It appears likely that the tubular quartz lamp in a suitable reflector[1] would match the shape of distribution in Fig. 2, with about one-third more peak candlepower per watt of input.

In dealing with light flux utilization from extended linear sources mounted either end-to-end or intermittently, it seems appropriate to call attention to the value of the "sector flux" concept, such as that applied by Skootsky and Brass in their paper on tunnel lighting.[2]

1. Allen, Carl J. and Paugh, Ronald L.: "Applications of the Quartz Lighting Lamp," ILLUMINATING ENGINEERING, Vol. LIV, No. 12, pp. 741-748 (December, 1959).
2. Skootsky, Harold and Brass, John R.: "Versatile Lighting System for Highway Tunnels," ILLUMINATING ENGINEERING, Vol. LV, No. 3, pp. 147-154 (March 1960).

S. C. PEEK:** In answer to Mr. Rex, luminaire brightness above cutoff was measured normal to the luminaire. Brightness at other lateral angles will be less due to reflection from the window, greater at angles other than normal.

Professor Finch's comment on the inaccuracy of the equation $E = \frac{\omega B}{\pi}$ for large values of ω is correct. I wished to show the importance of brightness and the simpler equation accomplished this. It separates the source size and its brightness. The identity of these two independent variables is lost in the beam candlepower equation and, therefore, the former is more useful and fundamental to the designer of reflectors.

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**Author.

INSTALLATION AT FIRST NATIONAL BANK DRIVE-IN OFFICE,
MASON CITY, IOWA

Lighting a Drive-In Bank

LIGHTING OBJECTIVE: To provide illumination for attraction and advertising purposes and for surround lighting for nighttime operation of drive-in banking facilities.

GENERAL INFORMATION: Fig. 2 shows a plan of the saw-toothed canopy-roof and the two teller locations. The underside of the canopy-roof is white brushed cement (75 per cent reflectance). The exterior walls of the teller stations are green marble (8 per cent reflectance). Raised black letters are mounted on the white brushed cement canopy face shown at the left in the above photograph.

INSTALLATION: General lighting in the driveway and other surrounds at the teller locations is provided by Revere Electric Mfg. Co. Fluoresign Outdoor Luminaires mounted at the lower edge of the two vertical portions of the saw-toothed canopy-roof (see Fig. 3). The underside of the outer section is illuminated by one catalog No. 8662-28, equipped with two 96-inch T-12 and two 72-inch T-12 cool white high-output fluorescent lamps. The underside of the inner section is illuminated by one catalog No. 8662-24, equipped with three 96-inch T-12 cool white high-output fluorescent lamps. Glass enclosure shields, catalog No. 8658, are used with both units for increased light output in cold weather and to aid in maintaining clean lamps and reflectors. The resulting maintained level of illumination from the illuminated underside of the canopy-roof is 29 footcandles on the driveway and 16 footcandles (vertical) half way up the green marble walls.

Additional attraction and advertising lighting is provided by three Steber Mfg. Co. catalog

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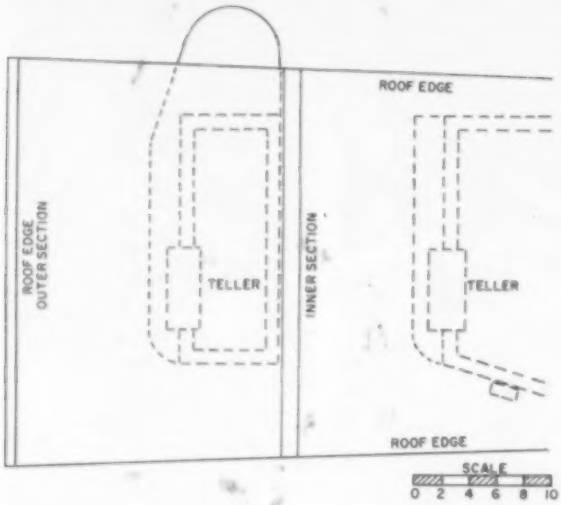
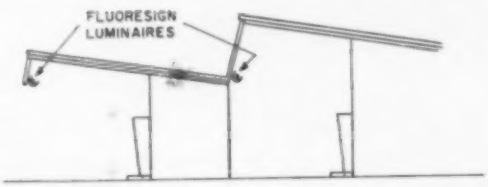


Figure 2 (left). Plan view showing saw-toothed canopy-roof and tellers' locations.

Figure 3 (below). Section showing approximate location of outdoor fluorescent luminaires.



No. GL 413 hooded units, each equipped with one 100-watt incandescent lamp, located along the edge of the driveway, and by two Stonco Electric Products Co. catalog No. CLD-1500 weatherproof units, each equipped with one 150-watt PAR-38 spot lamp, located at ground level and aimed for illuminating the canopy sign.

The neon back-lighted 23-foot tall red plastic "1st" sign helps in the over-all lighting scheme to establish the First National Bank of Mason City as a modern and progressive business.

Lighting designed by A. E. Krueger and R. C. Holcombe, Interstate Power Co., Dubuque, Iowa. Electrical work and installation by Determan Electrical Contractors and Berglund and Bianco, Architects, of Mason City, Iowa.

Lighting data submitted by A. E. Krueger as an illustration of good lighting practice and to aid in the design of similar installations.

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Performance of

Air-Handling Troffers

By ELDEN H. WITTE
BENJAMIN S. BENSON, JR.

To appraise the application results of combination light and air troffers, the authors studied a considerable number of installations of such equipment in use for periods up to three years. Results reported include measured conditions of air movement and maintenance, dirt collection and other practical elements of this newest of lighting and air-handling systems.

COMBINATION light and air troffers, having been in serious commercial use for somewhat over three years at the present writing, were past due for a serious "pulse-taking" to find out the state of their welfare, and a close scrutiny to observe the behavior patterns developed during this period.

Installations tested were chosen at random in the area between the Mississippi River and the East Coast. As shown in Table I, the sampling included a variety of environments, although all installations were offices with one exception—a company cafeteria. All troffers were of the general type shown in Fig. 1. Air enters the lamp chamber, but is so directed as to bypass the lamps and flow along the outside walls of the troffer, leaving the luminaire through the outer rows of louver vanes or, in the case of glass enclosed troffers, thorugh a series of shielded apertures along each side of the door frame. Both one- and two-foot-wide units with various numbers of lamps were included in the survey.

The investigation procedure was to visit various installations of air handling troffers in service from one to three years, ask the user for his evaluation of the system, obtain available design data for air performance, measure air velocities in the occupied zone, listen for noise and measure and photograph dirt collection.

Drafts

While user evaluation is reflected throughout this report, it is worthy of note that few people working under these air-handling troffer installations were cognizant of the fact that the lighting equipment supplied air as well as light—a good indication that the systems were generally free of drafts. This fact was amply supported by an exploration of these areas with an air velocity meter at a level six feet above the floor. Under the conditions found, a majority of installations registered linear velocities of not over 25 feet per minute. Some installations recorded an occasional reading of 50 feet per minute. One installation indicated a high spot of just over 100 feet per minute and a person standing in this spot was sensible of slight air motion at head level. It is the general consensus of opinion among air-conditioning engineers that linear air velocities of not over 65 feet per minute can be considered good practice.[1]

Noise

One of the possible problems with air diffusing equipment is the generation of noise. Air rushing past an edge can set up audible sound much as a

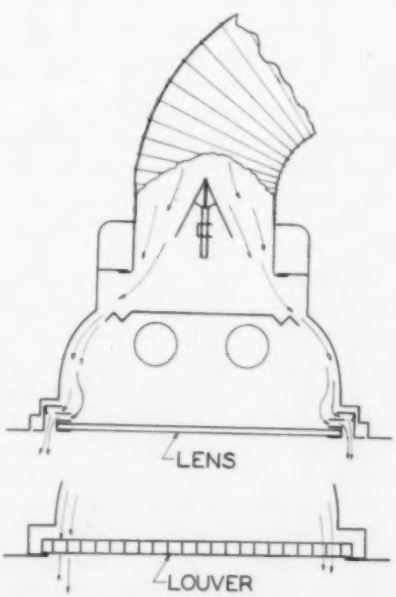


Figure 1. Cross-section of air-handling troffer with lens or louver enclosure.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHORS: Benjamin Division, Thomas Industries, Inc., Des Plaines, Ill. Accepted by the Papers Committee as a Transaction of the IES.

small boy whistling between his teeth. While space requirements prevented the carrying about of sound meter gear, an aural survey of the installations encountered indicated no apparent sound attributable to the air-handling troffers. The fact that some installations were observed after hours when the ambient noise was at a low ebb indicated low-noise-level air distribution for the lighting equipment.

Color

Whenever fluorescent lamps operate in an enclosure such as a troffer, mutual heating of lamps and ballast equipment causes lamp temperatures to rise and two things happen (among others): the light output is reduced and the lamp experiences a color shift towards the white. When the lamps in a troffer are cooled by having air passing either through or around the outside of the lamp cavity, they will generally regain some of their lost light output and shift back towards the pink. With all troffers acting as air inlets this color shift would be invisible since there would be no "standard" of comparison. An installation where some troffers are handling air and others are not provides a slight difference of color between troffers. Since few installations have all troffers acting as air inlets most installations observed had discernable color differences, but no apparent significance was given to this fact by the users.

Maintenance Factors

Although considerable research has been done on the subject of lighting maintenance, the applicability of previous findings, assumptions and their extrapolations to the air-handling troffer becomes most tenuous. The extra element of air passing through the lamp cavity adds the variables of the effect of air temperature, velocity and direction on the dirt accumulation, amount and pattern.

The method selected for the determination of maintenance factors for the several installations called for photometering representative luminaires before and after cleaning to determine the depreciation in light output due to dirt accumulation during the elapsed time since the last cleaning. The dirt depreciation component was then combined with a lamp depreciation component to obtain a final maintenance factor in the manner suggested by Gaetjens[2] and other earlier writers on the subject. This method does ignore the effect of dirt accumulation on room surfaces which has sometimes been included as part of the maintenance factor. Earlier work would indicate that for troffer installations this factor would not be of appreciable significance.[3]

At each installation the actual test procedure was the same. A troffer in a typical part of the office was selected, measured for light output, thoroughly cleaned, reassembled and again measured for light output after stabilization. Because the light output of air-handling troffers is affected by a change in the velocity and temperature of the air being delivered, as well as the usual variables such as voltage, ambient temperature, etc., it was necessary to measure, at each step, the concurrent photometric performance of a "control" troffer which did not get cleaned.

Since an accumulation of dirt on light-controlling surfaces could change the distribution as well as the total light output, and since it was necessary to exclude any light from adjacent luminaires, an integrating device covering the entire troffer opening was indicated. A portable integrator was made of a folding corrugated cardboard trough lined with a high reflectance white paper and containing a shielded photocell connected to a microammeter. The integrator was held under the fixture as shown in Fig. 2. Since repeated readings were necessary to assure stabilized conditions, the integrator was indexed to the troffer to insure exact repositioning for each reading. The usual precautions regarding lamp reorientation, etc. were observed.

Table I shows a tabulation of each installation, the nature of the installation and the amount of dirt depreciation at the testing time. Where the data was accurately known the schedule for cleaning the air conditioning filter has also been tabulated. In some installations nearby static (non-air-handling) troffers were also measured and this information has been included. At first glance the

Figure 2. Portable integrator positioned for test reading.

TABLE I—Information on Installations Tested.

Troffer	Location	Type of Installation and Estimated Maintenance Conditions	Mounting Height Above Floor	Air Volume and Temperature Differential	Filter Service Schedule	Months of Service Since Last Cleaning	Depreciation Due to Dirt per cent	Troffer Type (Width and Shielding Media)
A	North Chicago, Ill.	General Office area in clean suburban location—Good	9'6"	80 cfm 15-degree differential	By instrument demand	8	11	12" Louver (Plastic)
B	De Kalb, Ill.	General Office area in rural location—Good	10'	70 cfm Temperature Variable*	Self Cleaning (wet type)	30	13	12" Louver (Plastic)
BB	De Kalb, Ill.	Over steam table in cafeteria—Poor	10'	70 cfm Temperature Variable*	Self Cleaning (wet type)	30	27	12" Louver (Plastic)
E	Indianapolis, Ind.	General Office area in clean city location—Good	10'6"	42 cfm Temperature Variable*	Every 12 weeks	8	6	12" Louver (Steel)
F	Indianapolis, Ind.	Private Office of architect in downtown office building—Good	9'6"	— Temperature Variable*	By instrument demand	23	15	12" Louver (Steel)
FF	Indianapolis, Ind.	Private Office of architect in downtown office building—Good	9'6"	Return	—	23	16	12" Louver (Steel)
K	Des Plaines, Ill.	I.B.M. room in suburban factory—Medium	9'2"	100 cfm Temperature Variable*	Every 15-30 days	36	35	24" Louver (Plastic)
C	Beloit, Wis.	Private Office in factory and foundry building in urban industrial area—Medium	10'	80-100 cfm Temperature Variable*	—	15	28	12" Glass
D	Columbus, Ind.	General Office area in factory building in urban industrial area—Medium	10'	52 cfm	Electrostatic plates serviced monthly	25	38	12" Glass
DD	Columbus, Ind.	General Office area in factory building in urban industrial area—Medium	10'	Static	—	25	23	12" Glass
H	Cleveland, Ohio	Small office in urban industrial district heavy atmospheric dirt—Poor	9'6"	50 cfm 20-degree differential	By instrument demand	22	48	12" Glass
J	Des Plaines, Ill.	General Office area in suburban factory—Good	10'	60 cfm Temperature Variable*	Every 15 to 30 days	36	26	12" Glass
JJ	Des Plaines, Ill.	General Office area in suburban factory—Good	10'	Static	—	36	24	12" Glass
N	Hoboken, N. J.	Conference room in factory building in heavy industrial area—Medium	9'6"	80 cfm Temperature Variable*	Every 2 weeks	18	30	12" Glass
G	Chicago, Ill.	General Office area in suburban industrial area—Medium	10'	98 cfm 20-degree differential	Every 7 weeks	24	26	24" Glass
GG	Chicago, Ill.	General Office area in suburban industrial area—Medium	10'	Static	—	24	19	24" Glass
L	Des Plaines, Ill.	General Office area in suburban location—Good	10'	100 cfm Temperature Variable*	Every 15 to 30 days	36	15	24" Glass
LL	Des Plaines, Ill.	General Office Area in suburban location—Good	10'	Static	—	36	16	24" Glass

*In these cases the temperature differential varies throughout the year, depending upon whether the air is cooled, heated or merely tempered.

data would seem to be more remarkable for its very spread than for any consistency which might exist. Refinement of the raw data, however, does reduce the spread and produces interesting results. Also, some installations warrant individual discussion.

The dirt depreciation shown in Table I reflects varying amounts of time for dirt accumulation. The simplest way to reduce these figures to a common level would be to choose, arbitrarily, a time period such as one year and, assuming a straight line relationship between time and dirt, increase or decrease all figures proportionately. Earlier work, however, would indicate that the straight line assumption is not valid.[4,5] While none of the earlier work was done with luminaires comparable to air-handling troffers, there was no reason to believe that a straight line relationship would hold here. There alternative would be to plot the dirt depreciation *vs.* time for each type of troffer and develop a curve which might be considered representative of "good," "medium" or "poor" conditions depending on the conditions prevailing. For example, troffers C, D and N were all 12-inch glass bottom luminaires located in atmospheres with more dirt than a normal office. Installation C was adjacent to a foundry where the foundry sand evidently chewed its way through the filter of the air conditioning system. Installation D suffered in that the

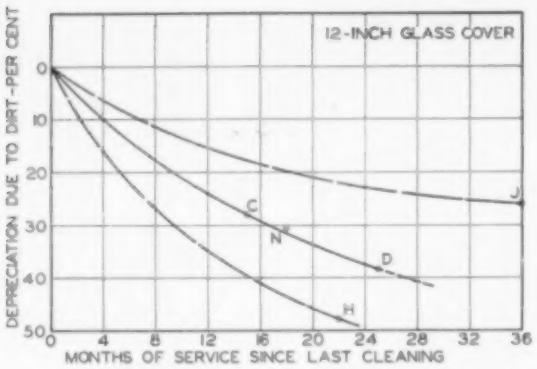


Figure 3. Dirt depreciation curves for 12-inch glass-enclosed air troffer as established by plotted test data.

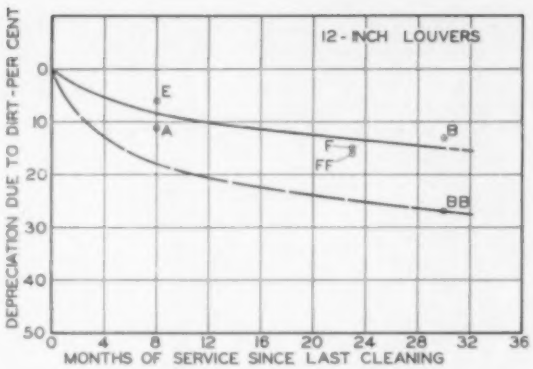


Figure 4. Dirt depreciation curves for 12-inch louvered air troffer as established by plotted test data.

exhaust from an engine testing laboratory was located near the air intake for the air conditioning system. Installation N was located in a heavy industrial area with a high concentration of air-born debris. The three, when plotted, do constitute a curve as shown in Fig. 3 which could be considered the dirt depreciation curve for "medium" conditions. Installation J used an identical fixture but in a clean area; hence, it could form one point of a similar but higher curve for "good" conditions. In similar fashion, luminaires A, B, E, F and FF were all 12-inch louvered troffers in clean locations. Their dirt depreciation points were such that a curve could be drawn to come in reasonable

TABLE II—Dirt Depreciation Factors and Maintenance Factors for Air-Handling Troffers.

Troffer	Dirt Depreciation For 12-Month Period	Estimated Maintenance Conditions	Maintenance Factor
A	.90	Good	.77
B	.90	Good	.77
BB	.79	Poor	.66
E	.90	Good	.77
F	.90	Good	.77
FF (return)	.90	Good	.77
K	.82	Medium	.68
C	.76	Medium	.63
D	.76	Medium	.63
H	.65	Poor	.54
J	.85	Good	.73
N	.76	Medium	.63
G	.81	Medium	.67
L	.90	Good	.77

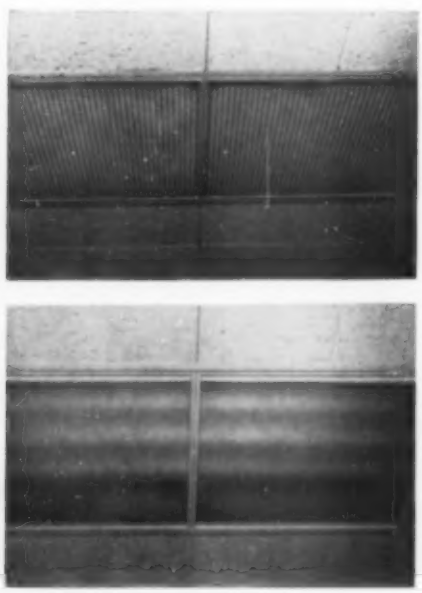
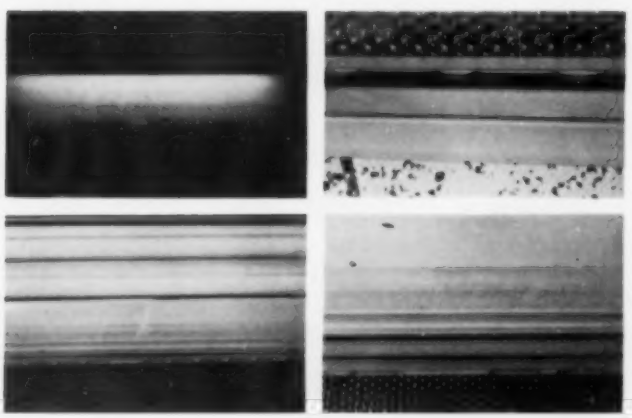


Figure 5 (left). Louvered and glass-enclosed air troffer, photographed before cleaning, illustrating absence of dirt on adjacent ceiling surfaces. Troffers K and L.

Figure 6 (below). Dirt pattern on glass-enclosed troffer (J). Top: normal view and close-up of air apertures. Bottom: Normal view and close-up of interior dirt collection.



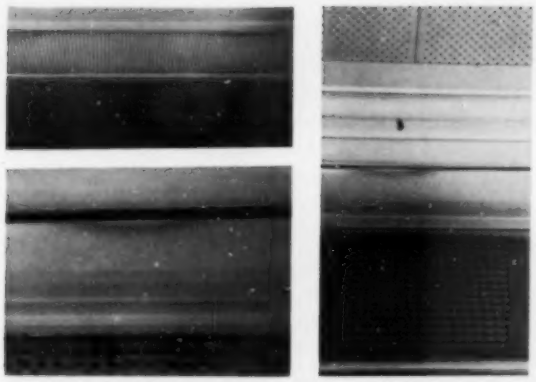


Figure 7. Dirt pattern on louvered air troffer (Installation A). Top left: Normal view of troffer. Right and bottom left: Normal and close-up view of interior with louver opened.

agreement with the data shown in Fig. 4. The BB troffer, located in conditions which could only be described as poor, must constitute one end of a lower curve. By repetition of the above a dirt depreciation factor at a constant time interval was determined and has been tabulated in Table II for an arbitrarily chosen 12-month period.

The definitions of "good" and "medium" maintenance factors are so unprecise as to be almost meaningless. Certain assumptions must be made before lamp depreciation factors can be applied to the dirt depreciation component. If it is assumed that "good" conditions, in addition to a clean location, involve annual cleaning and prompt lamp replacement at 80 per cent of rated life, the lamp depreciation would be approximately 0.86 at replacement time.[6] If "medium" conditions are assumed to include the annual cleaning but lamp replacement only at end of rated life, this factor would be reduced to 0.83.[6] These factors, applied to the dirt depreciation component, yield maintenance factors shown in the last column of Table II.

While the effect of dirt accumulation might be of prime interest to illuminating engineers, the appearance of the dirt pattern must also be considered. An obvious accumulation of dirt on a diffusing glass or an unsightly pile up of dirt on adjacent ceiling surfaces would detract from the over-all appearance of an installation.

Close examination of all tested installations detected no apparent dirt on adjacent ceiling surfaces. Fig. 5 shows two photographs of typical installations taken with supplemental lighting on the ceiling to illustrate this.

The dirt collection pattern was consistent for each type of troffer with the exception of Installation C. Dirt deposits, when such existed, concentrated along the lower portions of the troffer side walls, on the inside of the troffer cover frame and at the air exits (slots in the door frame with glass enclosed troffers, the perimeter rows of cells for louvered units). Figs. 6 and 7 show these dirt patterns for glass and louvered troffers, respectively. The troffers in Installation C, the one exception, showed a considerable collection of dirt resting on the glass (Fig. 8). Investigation disclosed this to

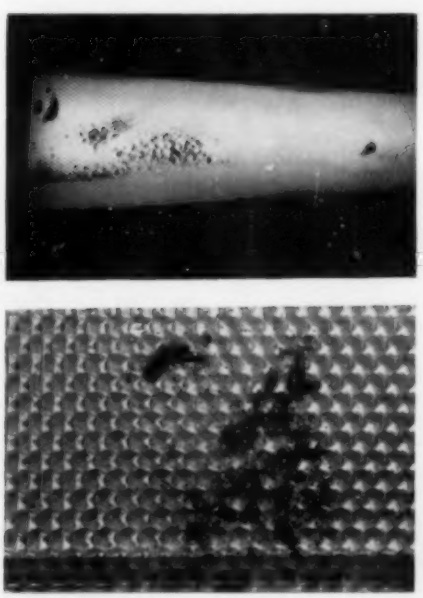


Figure 8 (left). Top: Collection of foundry sand inside troffer C. Bottom: Close-up of same troffer.

Figure 9 (below). Interior dirt pattern of air handling and static troffers (G and GG). Left: Top and side of air troffer. Right: Comparable views of static troffer.

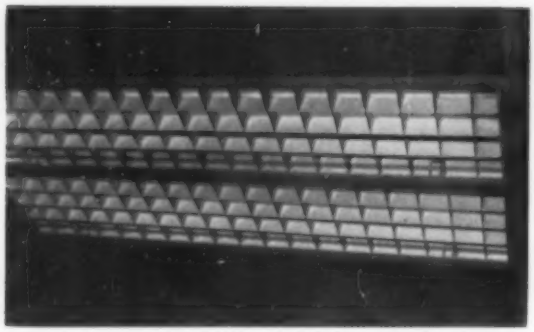


Figure 10. Adjacent air supply and air return troffers. (Troffers F and FF).

be foundry sand which had forced its way through the air conditioning filter system. Being too dry and too heavy to cling to the side walls, it had settled out in the bottom of the troffer. In no other case was there an obvious dirt collection visible through the glass. Discounting the dirt collection along the sides of the troffer, the dirt patterns within the rest of the luminaire did not differ from comparable non-air-handling troffers.

Fig. 9, showing an interior view of two troffers, only one of which had air, illustrates the similarity of the dirt patterns.

Troffers F and FF were two identical units mounted side-by-side and both handling air; one serving as a supply and the other as a return (Fig. 10). While the dirt collection was not heavy in either luminaire, it was slightly more noticeable on the supply troffer. As shown in Table I, however, the return troffer had suffered slightly more loss in light output.

Conclusions

From the results of the investigation it is apparent that the air-handling troffer is a well accepted tool for the illuminating engineer. The use of this type of lighting equipment as a source of low velocity air inlets results in both good air and lighting solutions.

The fact that practically every installation observed had good maintenance schedules for their air conditioning filters, even though the lighting equipment had not been touched for years, indicates that the air conditioning industry is getting its story across.

In addition to the usual elements which must be considered in determining a maintenance factor, the cleanliness of the air supply should be given attention. Comparison of the data for air-handling *vs.* static troffers in the same location illustrates that without knowledge of the air system, it cannot be predicted which troffer will have the better maintenance characteristics. Although admittedly limited, these data would indicate the maintenance factors listed in Table III for air-handling troffers of the type investigated. The figures in parentheses are those listed in the *IES Lighting Handbook*, Third Edition, for comparable static troffers. It appears that the maintenance factors listed in the *IES Lighting Handbook* for conventional troffers, when applied to air-handling troffers, will provide accuracy well within the limits normally expected of maintenance factors.

TABLE III—Maintenance Factors for Air-Handling Troffers of the Type Investigated.

Maintenance Factor	Louvered Troffer (12" Wide)	Louvered Troffer (24" Wide	Glass Covered (12" Wide)
Good	.77 (.75)*	—	.73 (.70)
Medium	— (.70)	.68	.63 (.65)
Poor	.66 (.65)	—	.54 (.55)

Maintenance Factor	Glass Covered (24" Wide)
Good	.77 (.70)
Medium	.67 (.65)
Poor	— (.55)

*Figures in parentheses are those listed in the *IES Lighting Handbook*, 3rd Edition, for comparable static troffers.

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1. *Heating, Ventilating and Air Conditioning Guide*, p. 268 (1959 Edition).
2. Gaetjens, A. K.: "A Guide to Realistic Maintenance Factors for Lighting Installations," *Transactions of the Illuminating Engineering Society*, Vol. XI, p. 307 (May, 1945).
3. Oetting, R. L., and Tuttle, J. W.: "Tests Aimed at Realistic Maintenance Factors," ILLUMINATING ENGINEERING, Vol. L, No. 5, p. 242 (May, 1953).
4. Moon, P. and Spencer, D. E.: "Maintenance Factors," *Transactions of the Illuminating Engineering Society*, Vol. XLI, p. 211 (March, 1946).
5. Egeler, C. E. and Vanden Boom, R. F.: "Maintenance of Industrial Lighting," ILLUMINATING ENGINEERING, Vol. XLVI, No. 10, p. 522, (October, 1951).
6. *IES Lighting Handbook*, Third Edition, p. 8-56, published by Illuminating Engineering Society, New York, N. Y., 1959.

DISCUSSION

MURRAY L. QUIN:* Some further statements on the color shift of lamps in combination troffers seem desirable. The authors have indicated a fluorescent lamp color shift toward the white when operated in the higher ambient temperatures generally encountered in static, or non-air-handling troffers. More precisely, color shift would be in the direction of one of the three primary colors in a chromaticity diagram. C. W. Jerome[1] has shown that lamp color shift with temperature is due to a change in the relative amounts of visible mercury and phosphor radiation. As temperatures increase, the mercury arc brightness increases and phosphor brightness decreases, resulting in a shift toward the green. Within the range of temperatures encountered, however, this no doubt moves into the range of equal energy white to the observer. Conversely, as the ambient temperature decreases, the mercury arc brightness

*Day-Brite Lighting, Inc., St. Louis, Mo.

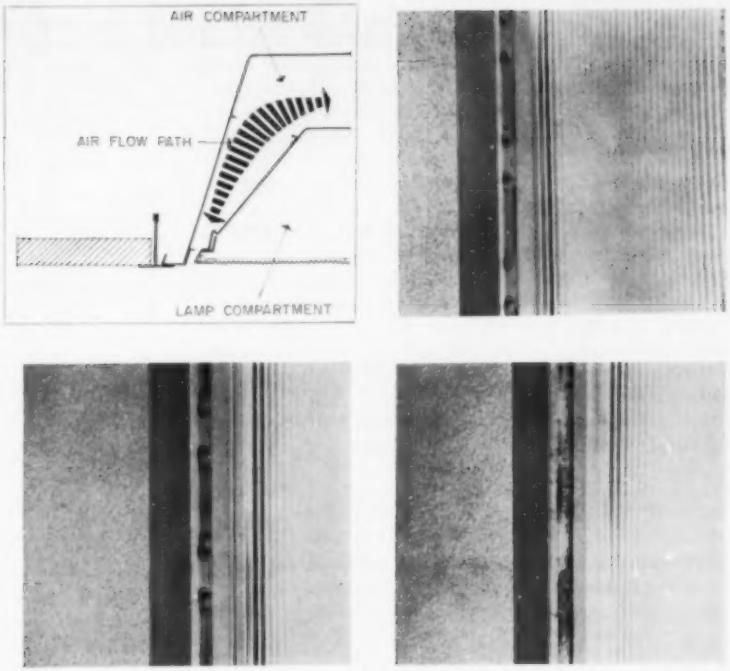

Figure A (Quin discussion). Dirt patterns related to troffer cross section after continuous operation. Top right: after eight months, supply. Bottom left: after 14 months, supply. Bottom right: after 14 months, return.

drops off more rapidly than the brightness of the phosphor emission and the color shifts toward the red, as noted by the authors.

It should be noted, however, that standard cool white lamps are more stable in this respect than are standard warm white lamps. By comparison, controlled laboratory experiments have shown the detectable color shift of warm white lamps to be approximately twice that of cool white lamps. Thus, under identical conditions, it is possible for troffers with standard cool white lamps to handle two times the cooling capacity of identical units equipped with standard warm white lamps in terms of color shift. Observations indicate that differences in equipment design, *i.e.*, air passing through or around the outside of the lamp compartment, can materially affect this relationship. It could also be expected that the lens and louver enclosed troffers illustrated in Fig. 1 would show a degree of this ratio favoring the cool white color. Since marketing sources report standard cool white to be the most widely used lamp color, it seems likely that this lamp was used in some of the installations surveyed by the authors. Although it was noted that most installations observed had discernible color differences, perhaps the authors could comment on any observed differences with respect to these two lamp colors.

In a paralleling study of performance characteristics, we established a work room installation of three 24-inch-wide troffers in a continuous row. The center unit remained static, one end unit returned room air and the opposite end unit was connected for supply. The supply air temperature varied, but both supply and return troffers handled 125 cfm. Each troffer was equipped with a prismatic plastic enclosure. Although the Underwriters' Laboratories have subsequently concluded that no combustible material with a flame spread rating of over 25, or a smoke developed rating of over 50, may be used within six inches of the air flow path, the original enclosures were left in place for test purposes.

After 14 months of continuous operation under conditions which, at best, could be described as "medium," the three troffers were lifted from the grid-type ceiling, photometered in the laboratory, cleaned and tested again. We found the following depreciation due to dirt: supply, .27; return, .28; static, .30.

Thus, after 10,000 hours' operation, the air-handling troffers fared slightly better than the static troffer. We attribute this to the curtain of moving air around the outside of the lamp compartment (Fig. A), acting as a barrier to the normal convection currents which carry dirt into static troffers. Further, as shown in Fig. A, dirt impingement was restricted to inlet and outlet apertures instead of lighting or ceiling surfaces.

It is encouraging to note the number of installations wherein general conditions and filter service were maintained. The fact that air-handling troffers can perform on a par with static troffers will be welcome information to engineers of both professions.

1. Jerome, C. W.: "Effect of Temperature on Electrical and Color Parameters of 40T12 Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLIX, No. 1, p. 237 (May 1954).

W. S. FISHER:* This paper provides some much-needed data, since it has been my experience that the subject of air-handling troffers can never be discussed without raising the question of maintenance. It is reassuring, too, to find that troffers with air passing through them, either for supply or return, have maintenance characteristics similar to the static troffers. It appears, though, that one possible clincher for this point was overlooked: in the test installations, the dirt collection on static troffers could have been measured and compared with that of the air-handling units, instead of making comparisons with *IES Lighting Handbook* figures.

*General Electric Co., Nela Park, Cleveland, Ohio.

Our experience with the maintenance of the integrated lighting-heating-cooling system at Nela Park,[1] reinforces the authors' conclusions. This system employs four PG-17 lamps in 24-inch-wide louvered troffers through which ventilation waste air is exhausted. The air passing through the troffers makes it practical to employ lighting units of this wattage loading and also takes nearly half of the lighting heat out of the luminaire before it gets into the occupied space.

While this room is not occupied full time as an office, it frequently gets very heavy occupancy, with 50 to 60 people —many of them smoking—in an area of slightly less than 900 square feet. Periodic inspection of the luminaire reflector surfaces and lamps reveals very little dirt collection on these surfaces. I am persuaded that dirt collection on air-handling troffers will *not* be a serious problem in most installations.

In commenting on air-handling troffers, I could not pass by the chance to suggest the opportunities which luminaires of this type open up regarding *real integration* of the lighting and thermal aspects of commercial and industrial environments. While employing some of the troffers to supply air offers certain advantages in many installations, I believe there are far greater opportunities in using *all the troffers* in an installation as air returns so as to control the lighting heat to advantage. In this way, the heat could be removed from a building when not needed, thereby reducing the air-conditioning load, or used when it is needed during the cold months of the year. This capitalizes to the fullest on the thermal properties of light sources, and has the economic advantage of reducing capital expenditures for cooling and heating equipment. Would it not be possible to use air-handling troffers, with relatively little modification, for such purposes?

1. Fisher, W. S. and Flynn, J. E.: "Integrated Lighting-Air Conditioning Systems," ILLUMINATING ENGINEERING, Vol. LIV, No. 10, p. 615 (October 1959).

E. H. WITTE AND B. S. BENSON, JR.:* We would like to thank Mr. Quin for his comments regarding the explanation of effect of tube wall temperature on the color of light. Our experience indicates that the amount of time necessary to completely explore the reasons for this phenomenon far transcends its relative importance to our topic. We, therefore, limited ourselves to the common terminology of a "pink" or a "white" color shift. Regarding Mr. Quin's comments on cool white *vs.* warm white, the cool white lamp is more stable in this respect than is the warm.

Mr. Quin's illustrations are certainly of interest. We hope that he plans to continue and enlarge his test program. Additional data under a variety of conditions will be very useful. It is gratifying to note from Mr. Quin's close-up photograph of the troffer air slot that his findings confirm our experience.

In answer to Mr. Fisher's question on dirt collection in static troffers, there is a limited amount of data on static troffers included in the paper. The Handbook figures were selected for comparison points because they constituted a familiar and generally accepted reference level.

In answer to Mr. Fisher's final question, it would be possible to use all luminaires in an installation as air returns.

*Authors.

Luminous Ceiling for Restaurant Lighting

High lighting efficiency of the luminous ceiling, combined with its usefulness in hiding unsightly overhead elements, has meant an ever-increasing popularity for this lighting technique. This installation in the Raleigh Restaurant, Boston, Mass. has provided a high level of illumination (68 fc average in service) which improves worker efficiency and induces rapid customer turnover. The 14- by 36-foot ceiling uses 40-watt, warm white, rapid-start lamps spaced on 24-inch centers in a 36-inch plenum. Prismatic vinyl plastic diffusing panels are supported by 2- by 4-foot modules of extruded aluminum T-bars.

Restaurant walls are burnt orange; murals, predominantly light tan; floor, light grey, yellow and tan; table tops, off-white plastic laminate. Photo and data courtesy B. F. Goodrich Co., Watertown, Mass.

Maintenance Factors for Interior Lighting

By R. N. EDWARDS, JR.

There is no IES recommended practice for determining minimum maintained illumination levels. This paper proposes that a component maintenance factor be recommended which includes maximum lamp lumen depreciation and maximum luminaire dirt depreciation; coefficients of utilization should be based on minimum in-service room surface reflectances. Each of these three factors is discussed and methods of calculation are exemplified. Test data presented for air-conditioned offices indicate that enclosed recessed units can be cleaner than louvered recessed units and that suspension-mounted louvered units are least affected by dirt accumulation.

MINIMUM MAINTAINED footcandles—this is now the recommended practice of the IES. The current method of calculating the maintained-in-service illumination level is one whereby a single maintenance factor is used. This single factor is supposed to combine lamp lumen depreciation with the loss of light due to dirt accumulation on fixtures, lamps, and room surfaces. If one desires to calculate minimum maintained footcandles, it follows that the maintenance factor should represent the maximum loss of light which will occur. There is no recommended practice for determining such a factor.

Maintenance factors are available from a number of sources: the *IES Lighting Handbook*, Third Edition; handbooks published by lighting equipment manufacturers; and some fixture manufacturers who list values on their photometric test reports. Maintenance factors are labeled good, medium, and poor; to quote from the *IES Lighting Handbook*:[1]

"*Good*—where work is clean and free of fumes, or dust, with luminaires scheduled to be cleaned frequently and lamps to be replaced systematically.

"*Medium*—where atmospheric conditions in the interior are less favorable, luminaires cleaned at fairly frequent intervals and lamps replaced only after burnout, or where atmospheric conditions are poor but maintenance is excellent.

"*Poor*—quite dirty location and work, with spasmodic or poor maintenance of equipment."

Table I lists such typical maintenance factors for fluorescent luminaires for interior lighting.

Such typical maintenance factors have always been criticized by some; such criticism is becoming more and more justifiable. In addition, maintenance factors have never been fully understood by all. To eliminate both of these detriments it is proposed that the present maintenance factor be broken down into its component parts.

The Component Maintenance Factor

Lamp Lumen Maintenance Factor

The first component part is lamp lumen maintenance. That lamps depreciate differently or at nonstandard rates is a well-known fact. Early investigators[2,3] realized this and reported upon it in their papers. Fig. 1 shows typical lumen depreciation curves for the 425-, 800-, and 1500-ma four- six- and eight-foot fluorescent lamps; Fig. 2 shows typical lumen depreciation curves for 400- and 1000-watt mercury lamps; Table II lists data for some typical 1000- and 1500-watt incandescent lamps.

If one compares the relative lumen maintenance factors in Fig. 1 at 7500 hours the 425-ma lamp has 100 per cent, the 800-ma lamp 93 per cent, and the 1500-ma lamp 78 per cent. If one compares the relative H36-15 and H12 lumen maintenance factors at 10,000 hours in Fig. 2, the H36-15 has 100 per cent and the H12 has 55 per cent. The author has seen photometric test reports with the three fluorescent lamps in similar industrial lumi-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHOR: Westinghouse Electric Corp., Cleveland, Ohio. Accepted by the Papers Committee as a Transaction of IES.

TABLE I — Typical Maintenance Factors for Interior Lighting Fluorescent Luminaires.[1]

Use	Distribution	Mounting	Shielding	Maintenance Factors Good	Medium	Poor
Commercial	Direct-Indirect	Suspension	Louver and Metal Side Panels	75	70	65
Commercial	Direct	Recessed	Louver	75	70	65
Commercial	Direct	Recessed	Control Lens	70	65	55
Industrial	Semi-Direct	Suspension	Louver	75	70	60

TABLE II—Typical Incandescent Lamp Lumen Maintenance Data.

Lamp	Rated Average Life	Approximate Per Cent Lumen Maintenance at 70 Per Cent Life
1000W PS-52 Clear C-7A Filament	1000	80
1000W PS-52 Clear 2-CC8 Filament	1000	90
1000W PS-52 Clear C-7A Filament	2500	80
1500W PS-52 Clear C-7A Filament	1000	70
1500W PS-52 Clear C-7A Filament	2500	70

naires and the good, medium, and poor maintenance factors were identical; the author has seen the same procedure used with the two mercury lamps. Obviously serious errors have occurred.

Fluorescent Lamps—Group Versus Random Replacement

Fluorescent lamps have a variable life depending upon the number of burning hours per start as shown in Fig. 3; the mortality curve is shown in Fig. 4. Before one can assign a minimum maintenance factor to a given fluorescent lighting installation, three things must be known: the type of lamp; the number of burning hours per start; the method of lamp replacement. The type of lamp will usually be one of the three shown in Fig. 1.

Example I

Assume that a burning cycle of 12 hours per start will be in service; from Fig. 3 the rated average life will be 12,000 hours. Further assume that lamps will be replaced on a group basis at 60 per cent of life or 7200 hours. From Fig. 1 the lumen maintenance factor for the group replaced 425-ma lamp is 0.84. By coincidence, the 800-ma and 1500-ma lamps will be lower in proportion to the relative values listed previously. This assumes that individual burnouts occurring before the group relamping cycle are replaced immediately with lamps that have lumen maintenance factors approximately equal to the rest of the lamps in service. If the 425-ma lamps are not group replaced, but individually replaced at burnout, the random replacement system will be in effect. What should the minimum maintenance factor be? There is apparently confusion on the subject since some lighting layout designers use mean lamp lumens. Mean lumens should be used—not for the lamp but for the installation. A look at the mortality curve, Fig. 4, shows that at rated average life, 50 per cent of the lamps will have been replaced and 50 per cent will be in service. As lamps fail they will be replaced; out of every 100 lamps one will be positioned on the mortality curve opposite each of the 100 survival factors. Thus, the mean lumens for the installation will be the lumen maintenance curve (in the example) integrated from $t = 0$ to $t = 24{,}000$ hours (t = time), assuming that at 200 per cent life all lamps will have been replaced. This integration can be done graphically in the following manner: find the mean lumens from $t = 0$ to $t = 12{,}000$ hours; find the mean lumens from $t = 12{,}000$ to $t = 24{,}000$ hours; average these two values. One lamp manufacturer states that mean lumens for rated average life are approximately the lumens at 40 per cent of that life. Applying this reasoning to this problem, the approximate per cent mean lumen depreciation factors are 0.87 for $t = 0$ to $t = 12{,}000$ and 0.75 for $t = 12{,}000$ to $t = 24{,}000$ for the 425-ma lamp. (For $t = 12{,}000$ to $t = 24{,}000$ the curve is a straight line and the mean value occurs at 18,000 hours.) The minimum lamp lumen maintenance factor for random replacement in this example is 0.81.

On the basis of lamp lumen depreciation alone

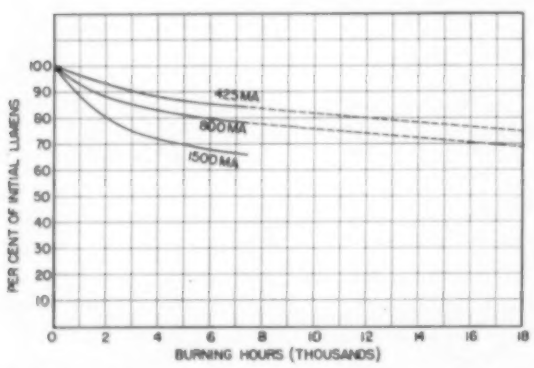

Figure 1. Curves illustrating lumen depreciation for typical fluorescent lamps having three or more burning hours per start. Data on the 1500-ma lamp is limited at the present time.

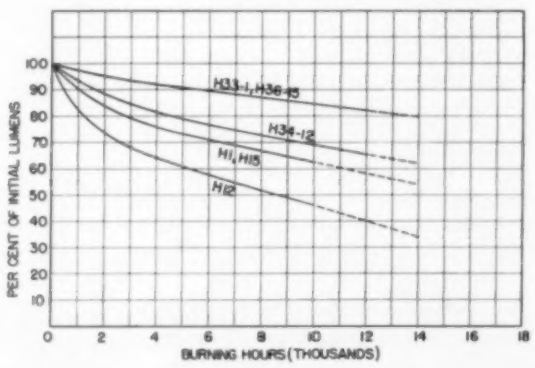

Figure 2. Curves showing lumen depreciation for typical mercury lamps having five or more burning hours per start. Results not released indicate depreciation curves are exponential, not reaching zero before burnout.

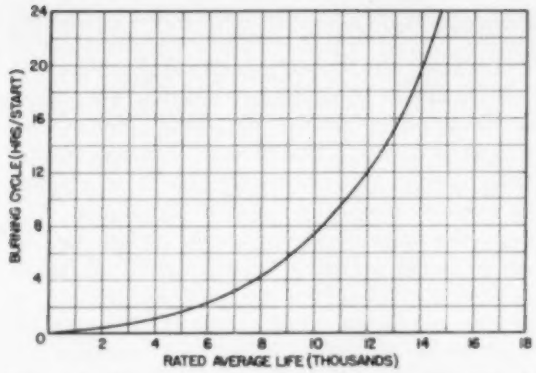

Figure 3. Curve showing how the rated average life of a fluorescent lamp varies with the number of hours it is burned for each time it is started.

the group replacement program with 425-ma lamps will provide four per cent more footcandles for the same number of lamps or, for equal footcandles, three and one-half per cent less lamps. Even if group replacement is done at 80 per cent of life, the minimum lumen depreciation will be 0.82 or higher than that for the random replacement system. Thus a random replacement compared to a group replacement will be generally more expensive (in a given installation that is designed to maintain minimum footcandles) for three reasons: one, the lamp lumen maintenance factor will be lower; two, the luminaires will not be washed as often, thus are subject to greater depreciation; and three, it is always cheaper to replace 100 lamps at one time than to replace, for example, one lamp 100 times, regardless of the labor rate. A random replacement system will not only have a higher initial installation cost, but also generally a higher annual maintenance cost per footcandle.

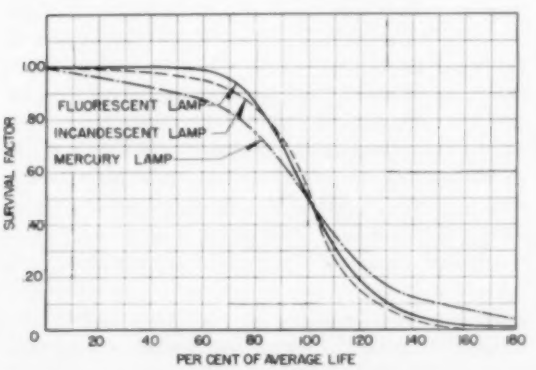

Figure 4. Typical lamp mortality curves for fluorescent and incandescent lamps. Curve is typical for H33-1, H36-15, H34-12 and similar type mercury lamps; other mercury types will not have as good a mortality curve; curve is extrapolated beyond 100 per cent average life.

TABLE III—Typical Life Values for Mercury Lamps in Figure 2.

Lamp	Economic Life*	Estimated Average Life**	Mean Lumens Thru Economic Life—Per Cent of Initial
H33-1	10,000	14,700	90
H36-15	10,000	14,700	90
H34-12	10,000	14,700	79
H1	7,000	13,700	78
H15	7,000	13,700	78
H12	7,000	13,700	70

*At 5 or more hours per start.
**Based on Mortality Studies and not Manufacturer's Ratings, at 5 or more hours per start.

Lamp Outage Factor

Neither of the lamp replacement system maintenance factors just discussed takes into account lamp outages which are not replaced immediately. If such is the case, a lamp-outage faoctor should be included as the second component in the overall maintenance factor. For example, if lamps are replaced after 5 per 100 have burned out, then the lamp-outage factor of 0.95 should be used.

Mercury Lamps— Group Versus Random Replacement

Table III lists typical average life, rated economic life, and the approximate per cent mean lumen maintenance for the rated economic life; the solid portion of the lumen maintenance curves in Fig. 2 terminate at rated average life. Economic life is a common term now used by lamp manufacturers.[4] When a lamp reaches economic life it is generally more economical to throw the lamp away and replace it with a new one; it might also be called the recommended group replacement life, based on cost of light calculations for typical installations. It should be noted that the average values in Table III are based upon the most reliable data available at this time. One lamp manufacturer indicates that the exact limits may not be known for some time since individual lamps last so long.[4]

Example II

Assume that a burning cycle of 12 hours per start will be in-service. Further assume that lamps will be replaced on a group basis at the end of rated economic life. From Fig. 2, the lumen maintenance factor for the H36-15 is 84 per cent at 10,000 hours. The mortality curve for this lamp, shown in Fig. 4 (also for H34-12 and H33-1 lamps) indicates that only 83 per cent of the initial lamps will be burning. It was assumed previously that these individual burnouts will be replaced immediately and that the lumen output of the replaced lamps will be approximately that of the existing lamps. This is not an absurd assumption because

it would be most economical to replace early lamp failures with new lamps; later failures with the best used lamps from previous group replacement.

The method of determining the random lamp-replacement maintenance factor is similar to that for fluorescent lamps. One must assume, however, that the mortality curve, Fig. 4, will terminate at approximately 200 per cent average life, and that the lumen maintenance curve will be a straight line when extrapolated. Again dividing the problem into two parts, this time $t = 0$ to $t = 12{,}000$ and $t = 12{,}000$ to $t = 29{,}400$ hours. Mean lumen depreciation for $t = 0$ to $t = 12{,}000$ is readily available from Table III and is 0.90; for $t = 12{,}000$ to $t = 29{,}400$ the mean occurs at $t = 20{,}700$ hours and is 0.71 (extrapolated). The weighted average of these two is 0.79 and represents mean lumen depreciation; this is the minimum lamp-lumen maintenance factor for this example:

$$\text{Mean lumen depreciation} = \frac{0.90 \times 12{,}000 + 0.71 \times (29{,}400 - 12{,}000)}{29{,}400} = 0.79$$

As in the case of fluorescent lamps the economic advantage of the group replacement program should be readily apparent. Since the purpose of this paper does not include cost comparison data, the reader is referred to a previous paper on this subject.[5]

Incandescent Lamps

Since lumen maintenance data for incandescent lamps, similar to Figs. 2 and 3, is not available, Table II is presented instead. It is readily apparent that to choose a single lumen-maintenance factor, representative of all incandescent lamps, would be a foolish mistake; yet this is currenly being done in the present method of assigning typical maintenance factors. In fact, the difference between the 1000-watt, 2-CC8 filament and the 1500-watt, C-7A filament (0.90 to 0.70) at 70 per cent of life, is greater than the difference between the good and poor typical maintenance factors one will find assigned to a high-bay luminaire.

Luminaire Maintenance Factor

Thus far it has been proposed that the first component of the component maintenance factor be lamp lumen maintenance and the second component lamp outages not immediately replaced; the third component is luminaire depreciation due to dirt accumulation on the lamps and fixture. It would be desirable to have luminaire depreciation curves in the same form as lamp lumen depreciation curves. Unfortunately a limited amount of field data is available on this subject.

Previous Test Data

Gaetjens[2] stated that random lamp replacement and luminaire cleaning will yield a maintained minimum illumination level; seven luminaire depreciation factors were combined with six different lamp depreciation factors in table form, yielding 42 results. Moon and Spencer[3] did a most thorough theoretical analysis on the average maintenance factor, studying lamp lumen depreciation, luminaire dirt depreciation, and room surface depreciation. Steiner[6] studied the effect of ventilating high-bay luminaires and showed composite data for mercury and incandescent lamps for both the ventilated and unventilated types in a dirty area (iron foundry) and a clean area (fixture assembly plant). Sell[7] presented test results of ventilated (240 square inches and 30 square inches) and unventilated fluorescent luminaires exposed to welding fumes in a sheet metal shop; the paper's title, "Ventilation — The Key to Self-Maintenance" is perhaps more dramatic than one would imagine at first. Egeler and VandenBoom[8] show data for unventilated fluorescent luminaires located in six low-bay areas (includes two in office) and six high-bay areas. Oetting and Tuttle[9] presented data for 13 different installed fluorescent luminaires, one type each in 13 non-air-conditioned offices. Taylor and Bradley[10] presented a more recent industrial study with fluorescent luminaires: one, unventilated; two, ventilated with 11 per cent uplight; three, ventilated, 27 per cent uplight; and four, ventilated, louvered, with 30 per cent uplight.

New Test Data

The purpose of the test was to find maximum dirt depreciation curves for commercial fluorescent luminaires in air-conditioned offices. To the maintenance data already published, Table IV is added. This should prove interesting to all. The units A, B, and C in Table IV were taken for testing from two air-conditioned offices to a photometric lab located in the same building. The move was made with extreme caution to be sure that no appreciable dirt would be lost. By visual observation it was noted that the luminaire reflecting surfaes, where dirty, had a greasy film of dust and dirt which would not shake off. The three units had been in service 33 months; unit A was in a small office with a window box air conditioner, units B and C were located in a second office, which had a grid type acoustical ceiling and air conditioning by anemostats. Since none of the luminaires was washed during this period and relamping was random, these conditions are representative of the "medium" maintenance factor in Table I.

TABLE I — Test Results: Commercial Fluorescent Luminaires in Air-Conditioned Offices. Unit A in one office; units B and C both in second office. Length of test—33 months with random replacement. Operating hours per day—12.

UNIT		A			B		C	
Over-all dimensions—length x width x height (inches)		48 $^{9}/_{16}$ x 15¾ x 4¾			48 x 11¾ x 4¾		24 x 11¾ x 4¾	
Finish		Baked white enamel			Baked white enamel		Baked white enamel	
Shielding		35° x 25° metal louver; illuminated metal side panels			Crystal, light-stabilized polystyrene control lens panel		White translucent, light-stabilized, polystyrene 45° x 45° louver. (Cell size is a $^{11}/_{16}$" cube.)	
Distribution		Direct-indirect			Direct		Direct	
Number and type of lamps		Four F40W			Three F40W		Three F20T12/W	
Mounting		Suspension—21" hanger			Recessed — inverted T (grid) acoustical ceiling			
Coefficients of Utilization × .01 for 80% Ceiling; 50% Walls; 30% Floor								
Room Ratio	(Index)	Dirty	Clean	New*	Dirty	Clean	Dirty	Clean
0.6	(J)	22	23	31	27	31	22	27
0.8	(I)	30	31	40	35	40	28	34
1.0	(H)	36	38	46	40	46	32	39
1.25	(G)	42	44	52	45	52	36	44
1.5	(F)	47	49	57	49	56	39	48
2.0	(E)	53	56	62	54	61	43	53
2.5	(D)	59	62	66	58	65	46	56
3.0	(C)	62	65	69	60	68	48	58
4.0	(B)	67	71	73	63	72	50	61
5.0	(A)	72	76	75	65	74	53	64
Efficiency (per cent)		77.1	80.8	65.9	57.4	65.0	46.2	56.4
Finish, average reflectance		85%	86%	**	***	87%	***	86%
Actual dirt depreciation		5%			12%		18%	

*Only unit with published photometric test report.
**Published specification for units A, B, and C new, is 85 per cent minimum.
***Dirt accumulation was not uniform; therefore, average reflectance value was not determined.

Discussion

It is obvious from Table IV that typical maintenance factors (Table I) are not representative of all conditions. In interpreting the data coefficients of utilization were calculated to determine if dirt accumulation on the luminaire will change the distribution provided by a control lens or louver; the results show no appreciable change. Note that Table IV shows efficiency and coefficients of utilization as new, dirty, and clean. "New" refers to the fixture manufacturer's published initial photometric curve; "dirty" refers to the luminaire as found in service; and "clean" refers to the luminaire with all component parts washed. It is interesting to note how close the "clean" restored luminaire efficiency returns to the published initial value. For unit A the luminaire maintenance factor is 0.95 and for random lamp replacement the lamp lumen maintenance factor is 0.81 (see Example I); the component maintenance factor is then 0.77, which, less room surface depreciation, is better than the "good" maintenance factor in Table I.

A look at the results for units B and C indicates that the standard assumption that recessed louvered units are better maintainers of light than enclosed ones seems to be in error. From this data one can immediately draw the conclusion that maintenance is much more involved and, perhaps, critical than one would imagine at first.

It has been assumed that more of the total dirt entering a recessed unit will fall out if the unit is louvered than if it has a plastic or glass enclosure. It follows then that a louvered unit will allow more dirt to enter the luminaire (convection currents due to heat). The test results, however, show that the enclosure does a better job of keeping dirt out in the first place than the louver does of allowing the dirt to fall back out once it gets in. That ventilation is the key to self-maintenance is evident. Unit A is considered fully ventilating, showing for all practical purposes dirt on only the 90- to 270-degree portion of the lamps. (Considerable dirt had settled on the top of the channel and on the ouside of the illuminated side panels, which were positioned on the luminaire at an angle of approximately 10 degrees. But this dirt will not materially effect the luminaire maintenance factor—only the luminaire appearance.) Units B and C are unventilated and show considerable depreciation. Almost without exception, test data by previous investigators show that the more ventilation provided, the higher the luminaire maintenance factor. In comparing results of units B and C the following should be kept in mind: the housing construction of B and C were identical except for length; ballasts were mounted in wiring channels located along either side; the two luminaires were operated under identical conditions. Unit B has a total depreciation of 12 per cent of which 51 per cent is

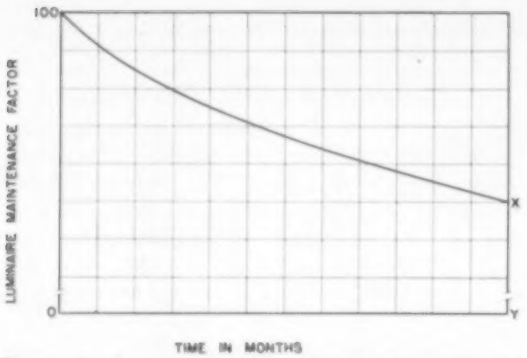

Figure 5. Assumed luminaire depreciation curve for Table IV, commercial, and clean industrial areas. Curve shape is taken from previous maintenance paper.[9]

attributed to the enclosure. Unit C has a total depreciation of 18 per cent of which 51.5 per cent is attributed to the plastic louver.

Determining Luminaire Maintenance Factors

It appears from a study of the referenced papers on maintenance factors that luminaire dirt depreciation follows an exponential function which approaches an asymptote other than zero; the asymptote is different for each luminaire. Fig. 5 shows the "average" curve in the Oetting-Tuttle[9] paper; the writer believes that a curve of this form can be used. For example, to determine the minimum luminaire maintenance factors for the units in Table IV for a given maintenance program, one assigns to time, Y, 33 months and to point X the minimum maintenance factor listed for each unit.

Example III

To determine the luminaire maintenance factor for unit B under a given set of conditions, one would assign to point Y a value of 33 months and to point X the maintenance factor of 0.88. For a group relamping program at 60 per cent of life, for an assumed burning cycle of 12 hours per start per day, the minimum lamp lumen maintenance factor is 0.84 (see Example I). If luminaires are washed only at relamping time, the minimum luminaire maintenance factor will occur after

$$\frac{0.60 \times 12{,}000 \text{ hours (life)}}{12 \text{ hours/day} \times 22 \text{ days/month}}$$

or approximately 27½ months. This luminaire maintenance factor is approximately 0.89 (taken from Fig. 5 by noting the value of the curve as it crosses the tenth vertical ordinate from 0). If the luminaires are also washed midway between the group relamping cycles, the maintenance factor is approximately 0.93. Assuming the latter, the luminaire maintenance factor 0.93 times 0.84 yields a component maintenance factor of 0.78. This will be the total component maintenance factor, assuming all burnouts between relamping cycles are replaced immediately with lamps having approximately the same depreciation as those still in service. The coefficient of utilization is chosen, based on assumed minimum in-service room surface reflectances (see Room Surface Depreciation below).

This is justified because in clean areas (mostly commercial and some industrial) luminaire dirt depreciation is so gradual over a period of months that the asymptote of the exponential curve will not be closely approached for many years. The luminaire appearance considerations and group relamping programs will require that the units be washed before this time occurs. Most of the referenced papers on maintenance have lumainaire factors in curve form, which can readily be used in the foregoing method; as much use as possible should be made of all previous maintenance work.

Room Surface Depreciation

The last component of maintenance to be considered is room surface depreciation. (Poor design of lighting component parts and/or misapplication of such is not considered; neither is the effect of absorption by room furnishings nor the effect of lighting installations with non-symmetrical layouts.) The present practice is to pick the coefficient of utilization on the basis of initial room surface reflectances and then hope the typical maintenance factor, Table I, will account for any loss in illumination level from depreciated room surfaces. A more logical approach would be to pick the coefficient of utilization based upon assumed minimum in-service room surface reflectances. The present form of the coefficient of utilization tables gives much data for various ceiling, wall, and floor reflectances. If one chooses reflectances which are not specifically listed, the coefficient of utilization can be readily interpolated. Thus, the component maintenance factor would include only the depreciation factors inherent in the fixtures and lamps in a given installation. Very little data is available concerning the depreciation of walls, ceilings, and floors under various conditions. One paint manufacturer has supplied the following information. Fourteen typical all-white test panels were attached to the wall of an air-conditioned office and left in service for ten and one-half months. Reflectances of these panels were recorded initially when new and compared to in-service reflectances, which included dirt accumulation. The mean depreciation of the fourteen panels was 1.56 per cent with a maximum of 2.74 per cent and a minimum of 0.46 per cent. It is interesting to note what the

final reflectances were: the maximum, 89.0 per cent and the minimum, 81.3 per cent. The maximum initial reflectance measured, for one panel, was 91.3 per cent. High quality white paints are now available for interior ceiling use, which have reflectances of 90 per cent or better. For office conditions similar to the above, suppose these paints depreciate at an average rate of 2 per cent per year; at the end of five years ceilings will not depreciate to 80 per cent, the maximum reflectance shown on the present commercial photometric test reports.

Conclusions and Recommendations

The author believes that much of the criticism and misunderstanding associated with the maintenance factor can be eliminated if the "typical" values are replaced by an IES recommended practice for determining a specific component minimum maintenance factor. This specific component minimum maintenance factor should consist basically of two parts: one, a lumen depreciation factor dependent upon the specific lamp used and the exact lamp replacement program; two, a dirt depreciation factor for the luminaire which includes both luminaire and lamps, dependent upon the exact cleaning schedule. Because room surface reflection depreciation is not a function of a fixture or lamp, it should be considered separately—by choosing the coefficient of utilization based upon assumed minimum in-service wall, ceiling, and floor reflection factors. Coefficient-of-utilization tables provide ample means for interpolating when required. The IES recommended practice for determining a component minimum maintenance factor could then be used by a lighting layout designer for the specific conditions of a given industrial or commercial area. The writer feels that the method outlined in this paper represents one possible solution; all previous maintenance papers should be used to the fullest extent.

For estimating purposes, a general component minimum maintenance factor will be required. Normally, group replacement cycles vary between 60 per cent and 80 per cent of rated average lamp life; a random replacement program will have a lamp lumen depreciation factor approximately that at 80 per cent of rated average life. Thus, a general component minimum maintenance factor could consist of the lamp lumen maintenance factor at 80 per cent of rated average life, and some assumed dirt depreciation factor for the luminaire. The rated average life of 10,000 to 12,000 hours for mercury and fluorescent lamps would be more realistic. Because of the variation among lamps in lumen depreciation and because of the variation among luminaires in dirt depreciation, the general component minimum maintenance factor should apply only to a given lamp-luminaire combination. The coefficient of utilization should again be chosen with minimum in-service room surface reflectances.

There is nothing typical about maintenance factors. As long as there are lamps which depreciate at different rates, as long as luminaires are of different designs, as long as luminaires are subject to various conditions, this will be true. Much has been said about maintenance, much more needs to be done.

Acknowledgements

The author wishes to thank the many persons who offered opinions and suggestions. In particular, thanks to J. A. Meacham of the Sherwin Williams Company, T. S. Madonia, W. S. Till, and R. F. Townsend for lamp information, and R. R. French of the Photometric Lab.

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DISCUSSION

JOHN J. NEIDHART:* I think that it should be recognized that the need for different lamp lumen depreciation factors for a given luminaire is of relatively recent origin. At the time that the typical maintenance factors for the Third Edition of the *IES Lighting Handbook* were prepared, there were only a few cases where it was likely that lamps having significantly different lumen depreciation might be used in any given typical luminaire for which data were provided.

The maintenance factors provided in Fig. 9-3 of the Handbook were derived to conform with the definition of maintenance factor appearing at the top of page 9-20 in

*The Miller Co., Illuminating Division, Meriden, Conn.

the Handbook; that is, they were derived to give the minimum illumination in service. They were obtained by multiplying the lamp lumen depreciation factor by the dirt depreciation factor in much the same manner as proposed by Mr. Edwards. The lumen depreciation factor was based upon the lumens at 70 per cent of life; this corresponds very closely with Mr. Edwards' suggestion that a random replacement program will have a lamp lumen depreciation factor approximately that at 80 per cent of rated average life.

I would be glad to send to anyone requesting them, a few illustrations as evidence of the fact that some of the factors mentioned by Mr. Edwards have not gone unrecognized. The first of these illustrations is our company's Lighting Design Data Sheet explaining how maintenance factors are derived and providing typical lamp lumen depreciation multipliers for the more-commonly-used lamps and estimated dirt depreciation multipliers for various types of industrial and commercial lighting equipment. The second illustration is from a catalog page and shows the different maintenance factors for the three basic types of fluorescent lamps that can be used in the luminaire for which the data is provided. Similarly, a third illustration shows very different maintenance factors for a mercury aluminum high-bay luminaire with either regular or premium lamps. Although these illustrations would probably be classified as oversimplifications by Mr. Edwards, they are offered as examples of steps that can be easily and immediately taken by anyone wishing to recognize differences in lamp lumen depreciation without giving up the simplicity of single number maintenance factors.

Despite this suggestion that we continue providing single number maintenance factors, I believe that it will ultimately be necessary to use multiple component maintenance factors, as suggested by Mr. Edwards. It seems to me, however, that before such a step can be taken the lamp companies will have to take the initiative by publishing appropriate lamp lumen depreciation factors for all lamps. I would further suggest that such factors be published in lamp schedules in lieu of the mean lumens currently provided or, if it seems more advisable, publish the lumens at 60 per cent and 80 per cent of life with the notation that whichever of these lumen ratings is appropriate for the relamping program is to be used in the lumen method formula. Although lamp lumen maintenance curves are currently available from the lamp companies on request, this information is not available easily enough to encourage the use of multiple component maintenance factors by the average lighting designer.

Concerning published information from the lamp companies, I have noted a disconcerting absence of published data regarding lamp life vs. burning hours per start. Mr. Edwards and others have consistently used lamp life figures that are significantly higher than published life ratings. Fig. 3 is the first example I have seen of lamp life plotted against the burning cycle. I would like to see more such data published in more generally available literature if some authors are going to persist in making cost analyses and other comparisons based upon life ratings that are other than published life ratings. It is our contention that if these long life ratings are valid enough to be used in a cost analysis or in comparisons such as Mr. Edwards has made, they should be valid enough to publish in lamp schedules. It follows, of course, that if they are not valid enough to publish in lamp schedules, these longer lives should not be used in *any* comparisons.

The new information on dirt depreciation provided in Table IV is most welcome, but I do not consider it sufficiently extensive to warrant drawing the general conclusion that all louvered troffers will accumulate dirt more rapidly than enclosed troffers in all atmospheres or that all direct-indirect units will have only five per cent depreciation due to dirt under all medium maintenance conditions. For one thing, I cannot help wondering how a metal louver would compare with a plastic louver. I would also like to see data from different rooms and environments before we completely reverse the concepts we have been using.

R. R. WYLIE:* It is to be hoped that the information contained in Mr. Edwards' paper will be taken to heart by manufacturers of lighting sources and lighting equipment, by representatives of both kinds of manufacturers, by application engineers and by users. Too many "loose" estimates and "competitive" calculations have resulted in a dim "bright new world." Who loses? Ultimately, the consumer and the electrical industry.

Accurate computation of specific lamp maintenance at lamp terminal hours is difficult. It is particularly hard to derive with gaseous discharge sources. This is due to factors beyond the control of the lamp manufacturer. The high current fluorescent sources are largely dependent upon the particular ballasting device used for the amount of light they deliver. Few ballasts operate the lamps at the currents or ambients at which the manufacturer rates the lamps. Although these factors may seem to be outside the scope of this paper, we feel they are important corollaries. These factors have been well documented in other papers; they should be more clearly recognized in illumination calculations.

Other recent papers[1, 2] have provided extensive documentation on the effect of ballasting of mercury lamps. The changes realized from manufacturers' standard ratings is of significant order. To achieve our "bright new world," realistic evaluation and publication of absolute rather than relative lamp ratings at specific time intervals should be earnestly sought by all application engineers. Mr. Edwards' paper serves to take us part way along the pathway to the realization of the goals of the Society.

1. Fraser, H. D., Unglert, M. C., Waldbauer, W. M. and Walick, J. A.: "How Operating Position and Circuit Variations Affect Mercury Lamp Characteristics, ILLUMINATING ENGINEERING, Vol. LVI, No. 3, Section II, p. 215 (March, 1961).
2. Yaeger, Joseph C. and Van Dusen, H. A., Jr.: "Factors Affecting the Efficiency of Street Lighting Systems," ILLUMINATING ENGINEERING, Vol. LVI, No. 4, p. 262 (April, 1961).

R. D. BRADLEY:** This is a very worthy paper dealing with a subject that has been much abused. Quite often we hesitate to use the information we have because custom may tend to make our figures "low" when comparisons are made.

In cost studies which I have made, it is customary to first assume a set of operating conditions as "typical." This may or may not fit when making random estimates but at least "pegs" it to a reference point.

We treat industrial areas on a one-, two- or three-shift basis: one shift at 9 hours per day, 5 days per week, 50 weeks per year or 2250 hours per year at 4½ hours per start; two shifts at 17 hours per day, 5 days per week, 50 weeks per year or 4250 hours per year at 8½ hours per start; three shifts at 24 hours per day, 6 days per week, 52 weeks per year or 7500 hours per year at 144 hours per

*Sylvania Electric Products, Inc., Salem, Mass.
**Day-Brite Lighting, Inc., St. Louis, Mo.

start (continuous). We also have stated conditions for general offices, schools and stores.

To be *practical* about these figures, one *must* key lamp replacements with cleaning operation. It is now necessary to arrive at a "per cent spot replacement" figure which may range from four per cent to thirteen per cent, depending upon the conditions and assumed maintenance labor costs. For instance, we assume that janitorial staffs in schools can spot replace up to the time for group change-out.

The remainder of our technique is quite similar to that set fourth by the author; three factors are used for determining the "maintenance factor" for minimum footcandles at any time.

We agree with the author that the room depreciation should be considered separately and can be done by extrapolation of published data.

I would like to encourage the author to *try* to set up a set of "standard" conditions similar to those mentioned above. There is a great need for some method which is realistic and yet precise enough to improve our maintenance factor technique.

MORGAN CHRISTENSEN:* The author is to be complimented on his choice of subject. Maintenance factors are usually the least accurate part of lighting design data and a great deal of work is needed to improve this situation.

The author's statement that when lamps are spot replaced the mean lumens for the installations used in Examples I and II will be the lumen maintenance curve integrated from $t=0$ to a time which is twice the average lamp life seems to be in error. Instead, the spot replacement mean lumens should be the factor which is calculated in the normal manner. The curve in Fig. A was derived to look into this further. This curve shows that the lumens in an installation continue to decrease out to about 75 per cent of lamp life. At this point, lamps begin to burn out rapidly and are replaced with new lamps. The number of new replacement lamps becomes great enough to cause the curve to start rising. This cycle repeats itself, each time to a lesser degree, until the lumens from the installation neglecting dirt become constant. This constant value is the mean lumens, which in this case is 89.5 per cent.

Fig. A is based on a lamp life of 7500 lumens instead of the 12,000 hours used in Examples I and II. If we use the method suggested in the paper for calculating spot relamping mean lumens for this lamp life, we obtain 90 per cent for $t=0$ to $t=7{,}500$ and 81 per cent for $t=7{,}500$ to $t=15{,}000$. The average of these two values is 85.5 per cent. This figure, compared to the correct value of 89.5 per cent, gives an example of the error obtained using the method shown in the paper.

The question which needs to be answered is whether to use the minimum number, which in this case was about 87 per cent at 75 per cent of lamp life, or the mean lumens. It would seem better to use the mean lumen figure, which is eventually approached as the constant output of the installation, rather than the minimum value which occurs only once during the early life of the installation.

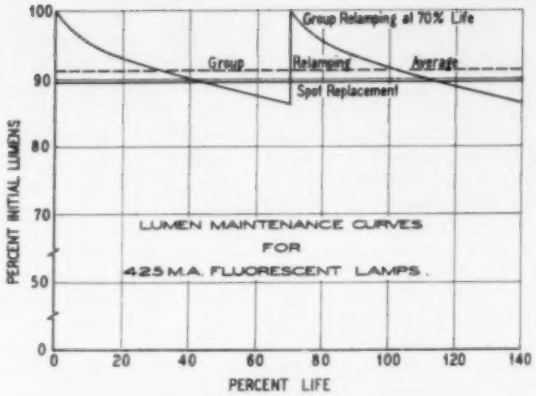


Figure B. (Christensen Discussion)

If the mean lumen value is used for spot-relamped installations, what should be used for group-relamped installations? Fig. B was drawn to help discuss this question. If we are to truly calculate *minimum* footcandles, we should use the minimum per cent lumen value. This value in this case is about 86 per cent at 70 per cent lamp life. Would this be the proper value? As was discussed previously, the average value for spot relamping is 89.5 per cent. As can be seen, the average value for group relamping is higher than this, being slightly more than 91 per cent.

The 86 per cent value would seem to penalize the group-relamped system, which actually would provide a greater total quantity of light. Since the end result from the lighting system is human performance, which increases with increased illumination and decreases with decreased illumination, the net result would seem to be more closely represented by an average figure proportional to the total quantity of light rather than a minimum figure. This might indicate additional studies on minimum as opposed to average maintained illumination.

The author's data on three types of commercial luminaires will make valuable additions to the slowly growing collection of such data. The author's approach to improved maintenance factors, by separating them into lumen depreciation, dirt depreciation, and room surface depreciation, seems to be good and he should be encouraged to continue this work.

*General Electric Co., Nela Park, Cleveland, Ohio.

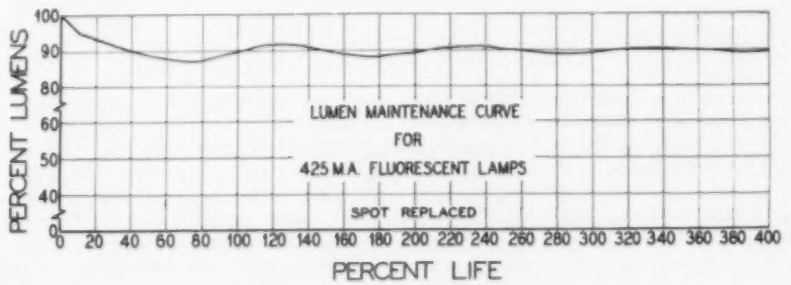


Figure A.
(Christensen Discussion)

R. N. Edwards, Jr.:* Mr. Neidhart has stated that the maintenance factors shown in Fig. 9-3 of the *IES Lighting Handbook* were derived by combining a dirt factor for the luminaire and lamp lumens at 70 per cent of life. It is suggested that this information be published in the next Handbook with the specific values listed.

The data in Fig. 3 of this paper are not new. Lamp companies usually publish fluorescent lamp life at 7500 hours, with it understood that the basis is three burning hours per start. For other operating conditions (six burning hours per start) a percentage increase of 25 per cent in life is noted. Fig. 3 is merely a summary of these data. The author does not believe lamp life of 7500 hours is always realistic. Since most plants and offices do not turn off lamps during lunch hours, the burning hours per start for one eight-hour workday can total 10 to 12.

As Mr. Neidhart mentions, the data in Table IV are not conclusive; however, it is felt that these data indicate that more information on luminaire dirt depreciation is required, especially in air-conditioned environments.

Mr. Wylie has mentioned some important considerations. These factors were not considered because they apply to the initial illumination level as well as the maintained level. Certainly, if commercially-available ballasts will not operate the lamps initially at rated values, such a depreciation should be included in calculations of illumination. Such factors should be applied to the initial lumen rating of the lamp used. The author agrees wholeheartedly with Mr. Wylie that there have been in the past "too many 'loose' estimates and 'competitive' calculations" of illumination.

Mr. Bradley cites cost studies which are always of interest. It is in analyses such as these that the effect of variables in maintenance factors is most important. If analyses are made using typical factors which assume identical maintenance factors for all lamps and environments, then the results are practically worthless. It is uncommon to find the end results of some analyses closer than the differences in realistic maintenance factors would have been, had these been used. I agree that "custom" will be a difficult barrier for a new maintenance factor technique to overcome.

Mr. Christensen has indicated that my method of determining random replacement lumen maintenance factors is in error. He further states that in calculating such a value one should use the "normal" method, which results in Fig. A.

The real question under debate is: What is the population of lamps once the random replacement system has cycled out? If there exists such a cycled out installation, how old are the individual lamps?

It has been assumed in this paper that the population of lamps will cycle out to 50/50, that is, 50 per cent of the lamps will be between $t = 0$ and $t =$ rated life, 50 per cent between $t =$ rated life and $t =$ twice rated life. This paper considered an installation of 100 lamps. It is not difficult to determine when these 100 lamps will fail, since one can be assigned to each of the 100 survival factors. Now, the question is when does the first replacement lamp fail, and the second replacement, and so on. I assumed that since the individual life of any one lamp is indeterminant, the average life of two successive lamps in a socket or pair of lampholders will be rated average life, and from then on lamps will fail at random, at varying ages that provide rated average life.

The "normal" method considers a large number of lamps, 10,000 for example. With reference to Fig. 4, it can be seen that the following will occur: at 60 per cent of life, 1 per cent of the lamps, or 100, will fail; at 70 per cent of life, 4 per cent more lamps, or 400, will fail; at 80 per cent of life, 7 per cent more lamps, or 700, fail; at 90 per cent of life, 17 per cent more lamps, or 1700, fail; at 100 per cent of life, 21 per cent more lamps, or 2100, fail; at 110 per cent of life 20 per cent more lamps, or 2000, fail; at 120 per cent of life, 12 per cent more lamps, or 1200, plus, fail.

One per cent of the first 100 lamp replacements, or one lamp, fails. In fact, after 180 per cent of life is reached some of the second replacements begin to fail before all of the original lamps have failed.

Mr. Christensen's Fig. A is the plot of lamp lumen maintenance out to 400 per cent rated life, where rated life is taken to be 7500 hours. His calculations show that the cycled-out value will be 89.5 per cent. Incidentally, the cycled-out answer for a 12,000-hour rated lamp life, using a computer and Mr. Christensen's procedure, is 87 per cent. For the group replacement cycle at 70 per cent of life, his calculations reveal that the average lumen maintenance from $t = 0$ to $t = 70$ per cent life is 91 per cent. By eliminating 93 out of every 100 lamps that normally burn longer than 70 per cent of life, the lumen maintenance factor is increased only 1.5 per cent. Also, using the "normal" method, the population of lamps at 500 per cent life will be approximately 90 per cent between $t = 0$ and $t =$ rated life, 10 per cent between $t =$ rated life and $t =$ twice rated life. In fact, out to 500 per cent of life, a 10,000-lamp installation will have approximately 42,000 replacements.

There are no field data to support either procedure, and it is doubtful whether such data will ever be available. I believe that before a final decision is made, a closer "statistical account" should be made of the random-replaced lighting installation. Many large lighting installations are composed of small areas where less than 100 lamps are contributing to the minimum maintained illumination. As one lamp manufacturer states concerning mortality curves "... well-established 'sampling fluctuation' laws applying to this general type of 'average performance' show that the frequency and extent of irregularities and departure from average performance increase as the number of lamps under consideraion decreases."

Fig. A is the first of that type I have ever seen in Illuminating Engineering. This indicates that much has been left unsaid and undone in the discussion of maintenance factors. That we are dealing with a sometimes vague and seemingly indeterminate subject is no justification for assuming that the problem cannot be solved. Maintenance factors are one of the oldest, most complicated, least understood, yet most commonly used, elements of IES.

This Society needs a recommended practice for determining maintenance factors.

*Author.

LIGHTING NEWS

Mary Webber Retires Honored by N. Y. Residence Forum

Miss Mary Webber, noted residential lighting authority, was honored by 35 members and guests of the New York Residence Lighting Forum at a testimonial luncheon on March 8. The luncheon marked Miss Webber's retirement, on April 1, after 40 years of service with the General Electric Co., Nela Park, Cleveland, Ohio. Berlon C. Cooper, eastern editor of *Electrical Construction and Maintenance* served as toastmaster for the occasion.

Miss Webber, one of five women IES Fellows, was a pioneer in home lighting educational programs and collaborated with the late E. W. Commery in much original work on home lighting techniques. She has been a member of IES since 1929 and has been active on the Residence Lighting Committee for many years. During her term as chairman, the committee developed the "Recommended Practice of Residence Lighting." In recognition of her services to IES and the home lighting industry, Miss Webber was elected to Fellow grade in 1955.

National Housing Center Sponsors Home Lighting Seminar

A two-hour seminar on home lighting techniques, developed by the National Housing Center, Washington, D. C., was tested on three different audiences of homemakers from the Washington area on April 24, 25 and 26. The program, which attracted a total audience of approximately 750 people, covered techniques of task, general and accent lighting, structural lighting methods, light sources and control media; advance planning requirements for wiring, switches and outlets and the coordination of light, color and decor. Speakers were Miss Rose Coakley, Superior Electric Co., Bristol, Conn.; Bernard Shields, Residential Customer Division, Potomac Electric Power Co. and C. Eugene Stephenson, past president, American Institute of Decorators.

The premiere seminars were sponsored by the Home Builders Association of Metropolitan Washington and the Potomac Electric Power Co. Similar programs are expected to be developed in other areas of the country by local home builder groups affiliated with the National Association of Home Builders.

Dorothy Nickerson Receives ISCC Godlove Award

Miss Dorothy Nickerson, color technologist with the U. S. Department of Agriculture, was presented with the Inter-Society Color Council's Godlove Award at the ISCC's 30th Annual Meeting at the Sheraton Hotel, Rochester, N. Y. on April 11.

The third recipient of the Award, Miss Nickerson is internationally known for her studies of the color rendering of light sources and for color standards perfected for classing cotton. She has developed the Nickerson Color Fan, a convenient systematic collection of 262 color chips used as color standards in horticulture and has adapted the Munsell color system to the solution of technical color problems.

Miss Nickerson is a past president and past secretary of the ISCC, a Fellow of IES and a Trustee of the Munsell Color Foundation. She is the author of more than 30 scientific papers in the field of color and has served on color committees of the Optical Society of America, the American Society for Testing Materials, IES and the International Commission on Illumination.

Dr. Deane B. Judd, National Bureau of Standards, Washington, D. C., and Ralph M. Evans, Eastman Kodak Co., Rochester, N. Y. were members of the committee which selected Miss Nickerson for the Award.

Floodlighting Institute Plans National Promotion Program

Announcement of a national floodlighting promotion campaign, to be conducted by the Floodlighting Institute, Cleveland, was made at the March 20 meeting of the Edison Electric Institute at the Edgewater Beach Hotel, Chicago. According to Edmond C. Power, director of the Institute, which is the public in-

RESIDENTIAL lighting specialist, Mary Webber (standing) who retired from General Electric Co. on April 1 was honored at a testimonial luncheon sponsored by the New York Residence Lighting Forum. Berlon C. Cooper (standing), *Electrical Construction and Maintenance*, served as toastmaster at the luncheon. Others at head table, from left: William F. Little, past chairman of IES Residence Lighting Committee and retired president of Electrical Testing Laboratories; Myrtle Fahsbender, director of residential lighting, Westinghouse Lamp Division, Bloomfield, N. J.; P. H. Ganther, sales district manager, General Electric Large Lamp Department, New York; Lillian Eddy, G-E, N. Y.

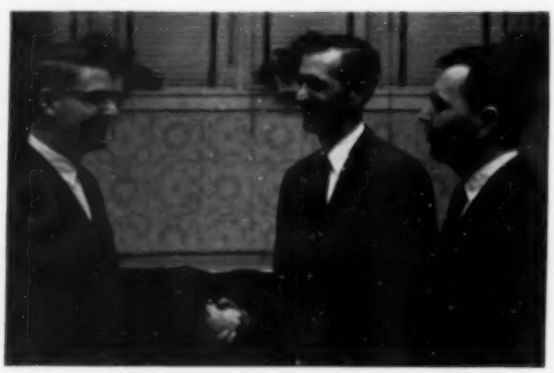
Here and There with ALC Contestants

New Jersey Section (above)—C. Johnson, first, Class II; H. Hiller, second, Class I; K. Huck, first, Class I; L. Ellis, tied for third, Class II; J. Hargis, contest chairman; A. Robinson, tied for third, Class II; W. Greenwood and H. Brennan, joint entry, second, Class II.

Cleveland Section—R. W. Traves (left, photo at left above), first place, Class I, and S. M. Mills (left, photo at left below), first place, Class II, receive prize checks from section chairman, Fred C. Winkler.

Philadelphia Section—Seated, l. to r.: Elizabeth Meehan, first, Class I; William Speed, section chairman; G. E. Watt, first, Class II. Standing: A. V. Schafer, ALC chairman; contestants C. G. Dunn, J. R. Rodisch, C. W. McQuiston, L. H. Fritz and R. F. Flood.

Western New York Section, Class II, Commercial—Judge George Butler; first-prize winner, Ed Cunningham; second prize, Joe Kellas; judge Carl Pollack.



Central New York Section—ALC chairman E. R. Hunt (left) congratulates first-prize winners Miles R. Smith (center), Residential and Donald M. Esthus, Commercial.

formation facility of the Floodlighting Section of the National Electrical Manufacturers Association, the program is designed to emphasize esthetic, cultural and commercial benefits of floodlighting.

To implement the program, four floodlighting brochures, covering public, industrial and civic buildings, monuments and landmarks, gardens and parks and schools and churches, and four postcard-size mailing pieces have been prepared. National and local newspaper and magazine advertisements have also been planned.

Promotion kits, available from the Floodlighting Institute, 12th Floor, 55 Public Square, Cleveland 13, Ohio, will also include a step-by-step action guide on "How to Promote Floodlighting."

Membership Certificate Offered By Golden Gate Lamplighters

The Lamplighters, active street lighting committee of the Golden Gate Section, have announced the development of a Lamplighter membership certificate. The certificate is available to all interested members at a cost of twenty-five cents.

The group, which takes its name from the lamplighters who maintained street lighting in the gaslight era, is an informal organization within IES Sections and Chapters, dedicated to the promotion of better street and highway lighting. No dues are collected. It received national recognition at a dinner held in connection with the 1959 National Technical Conference in San Francisco, when a group of street lighting engineers from all over the country took the Lamplighter Pledge and adopted a resolution to promote the formation of local Lamplighter groups.

The membership certificate may be obtained from James H. Burson, 410 Bush St., San Francisco 8, Calif.

Residence Lighting Forums Plan Membership Campaign

A program to stimulate the organization of new IES Residence Lighting Forums has been developed by the national Forums Committee. Initial organizational efforts are to be concentrated in areas where Academy of Lighting Arts courses have been conducted, since it is probable that the greatest impetus for the formation of new Forums will come from ALA instructors. Committee chairman Aileen Page has undertaken a campaign to coordinate the efforts of ALA instructors and IES Section/Chapter chairmen as the first step in planning the development of new groups.

In addition to its membership drive, the Forums Committee is developing a complete guide to Forum operation in the form of a ring-binder notebook containing procedural details, program and publicity activities and uses of IES publications in relation to residence lighting activity.

Engineering Secretaries Trained In Pittsburgh Junior College

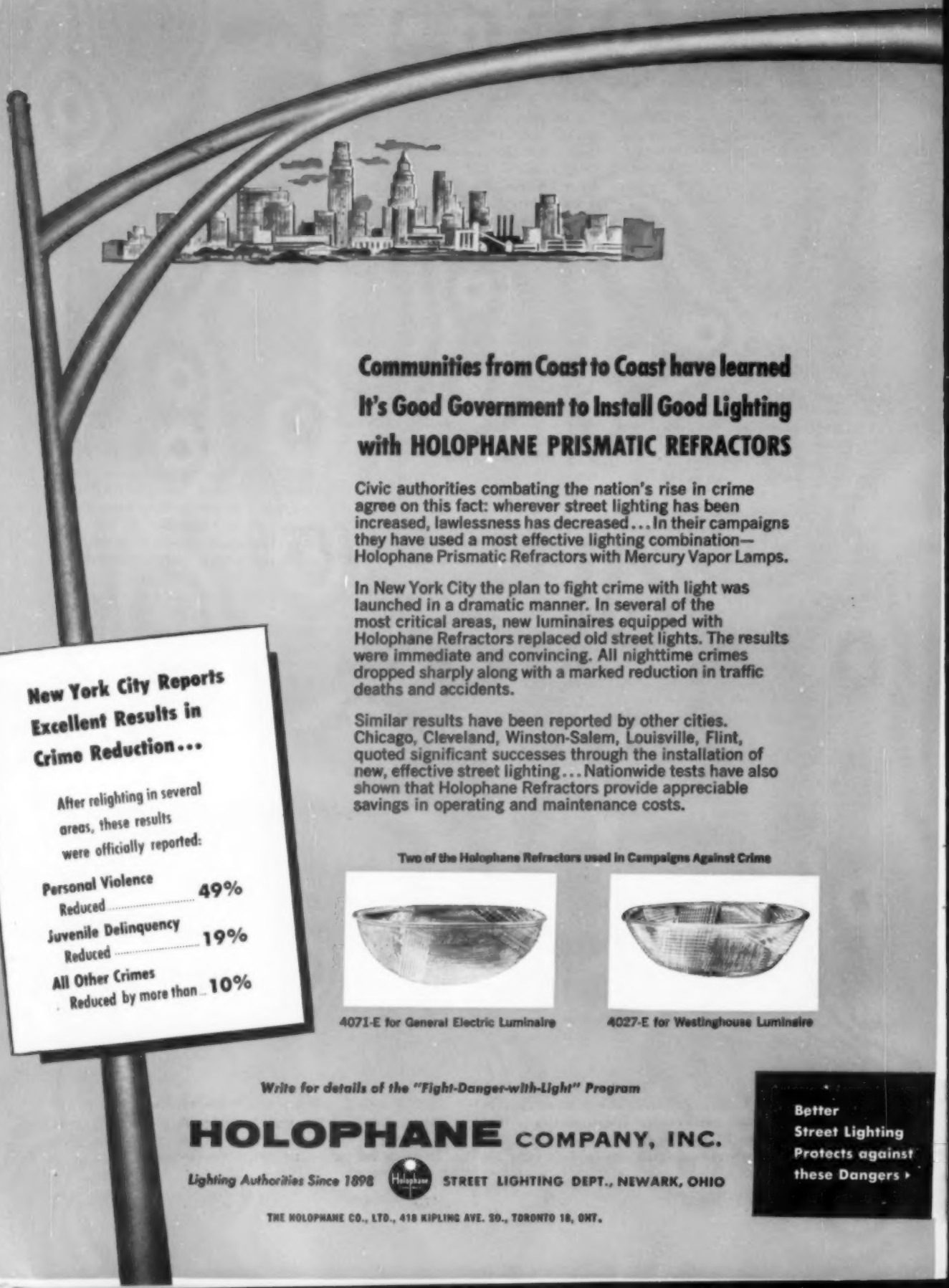
Specialized training for prospective engineering secretaries is available at the recently chartered Point Park Junior College in Pittsburgh, Pa. Begun about five years ago as a secretarial school, in response to the engineering profession's demand for secretaries trained in scientific terminology, the two-year school has now become a non-profit educational institution which grants associate degrees in arts or science.

1965 IES National Technical Conference has been scheduled for the Americana Hotel in New York City, August 29 to September 3. The 50-story Americana, shown in architect's rendering, is now under construction.

The curriculum includes the usual secretarial studies plus English, spelling, mathematics, filing, record keeping and "varitype" application. Typing is studied from specifications and shorthand from Civil Aeronautics Board reports. In addition the students are taught terminology of civil, mechanical, electrical, chemical, metallurgical, aero-

(Continued on page 12A)

IES PRESIDENT Richard G. Slauer was featured speaker at a lighting meeting for electrical contractors sponsored by the West Penn Power Co. in Greensburg, Pa. Mr. Slauer (right in photo at left) is shown here after his speech, with Don Thomas, Sylvania representative, Pittsburgh district (left) and H. R. Jones, commercial sales manager, West Penn Power Co. At right, the 120 electrical contractors present at the dinner meeting.



Communities from Coast to Coast have learned It's Good Government to Install Good Lighting with HOLOPHANE PRISMATIC REFRACTORS

Civic authorities combating the nation's rise in crime agree on this fact: wherever street lighting has been increased, lawlessness has decreased... In their campaigns they have used a most effective lighting combination—Holophane Prismatic Refractors with Mercury Vapor Lamps.

In New York City the plan to fight crime with light was launched in a dramatic manner. In several of the most critical areas, new luminaires equipped with Holophane Refractors replaced old street lights. The results were immediate and convincing. All nighttime crimes dropped sharply along with a marked reduction in traffic deaths and accidents.

Similar results have been reported by other cities. Chicago, Cleveland, Winston-Salem, Louisville, Flint, quoted significant successes through the installation of new, effective street lighting... Nationwide tests have also shown that Holophane Refractors provide appreciable savings in operating and maintenance costs.

New York City Reports Excellent Results in Crime Reduction...

After relighting in several areas, these results were officially reported:

Personal Violence Reduced	49%
Juvenile Delinquency Reduced	19%
All Other Crimes Reduced by more than	10%

Two of the Holophane Refractors used in Campaigns Against Crime

4071-E for General Electric Luminaire

4027-E for Westinghouse Luminaire

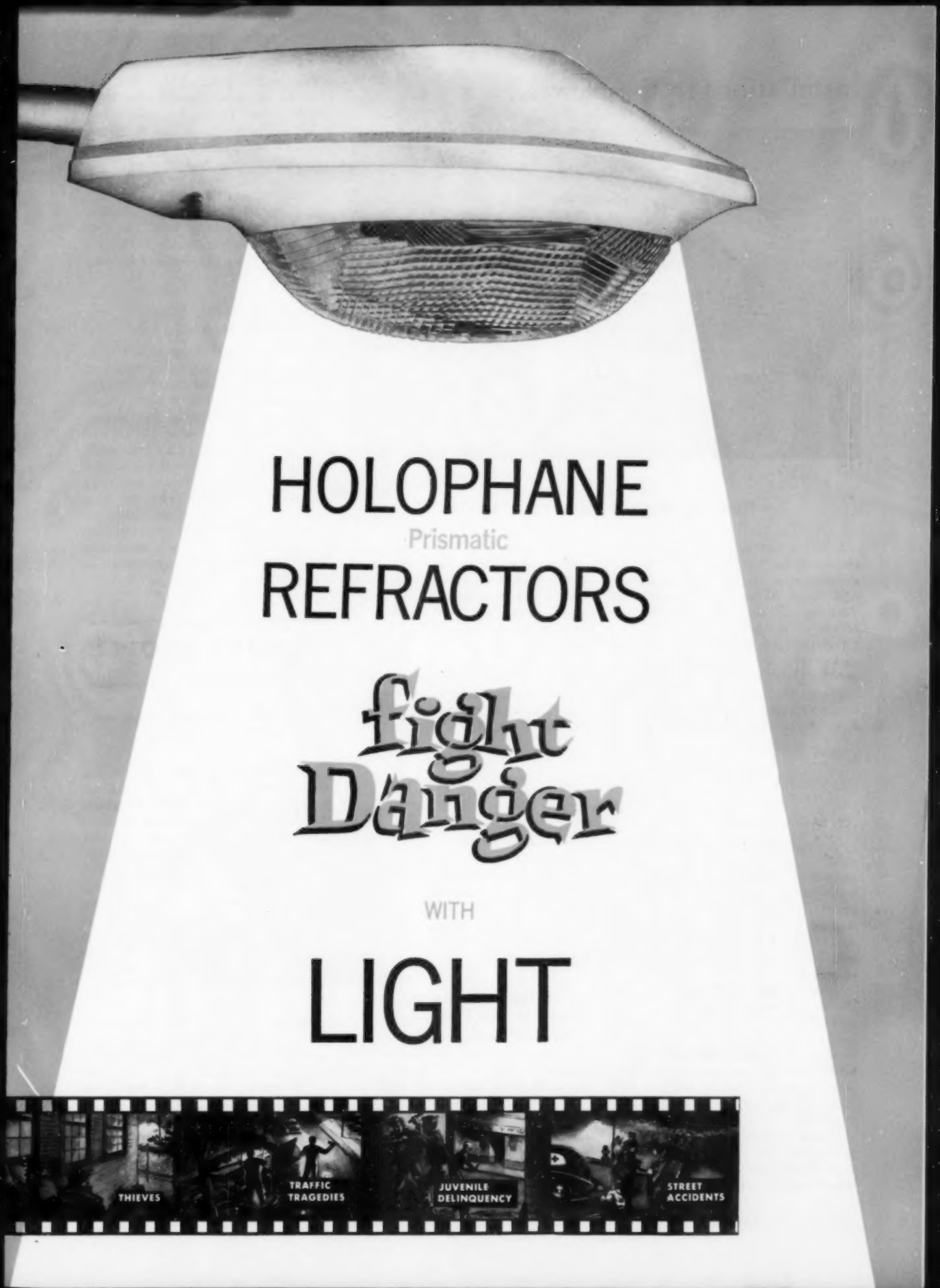
Write for details of the "Fight-Danger-with-Light" Program

HOLOPHANE COMPANY, INC.

Lighting Authorities Since 1898 STREET LIGHTING DEPT., NEWARK, OHIO

THE HOLOPHANE CO., LTD., 418 KIPLING AVE. SO., TORONTO 18, ONT.

Better Street Lighting Protects against these Dangers ›


HOLOPHANE
Prismatic
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fight
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WITH
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JUVENILE
DELINQUENCY
STREET
ACCIDENTS

Installations in the News...

New Sign Added to New York Skyline

A 24-foot-high neon sign which spells out the words "Time" and "Life" on an alternating pre-set cycle is a new addition to the rapidly changing New York City skyline. Located on the south facade of the new 48-story Time and Life Building in Rockefeller Center, the sign spans a 96-foot-long area under the building's roof line.

The double row of ½-inch white neon tubing outlining the letters projects only three inches from the building facade, with all supports and electrical equipment located inside the building wall. As a safety measure, the neon tubing is encased in a flexible sleeve of translucent material which will prevent pieces of damaged tubing from falling to the ground.

Illuminated each day from dusk to 1 a.m., the sign is clearly visible to airliners approaching the city from the South. Photo and data courtesy of Time, Inc., New York, N. Y.

(Continued from page 9A)

nautical and industrial engineering and a special engineering shorthand. Lab courses in chemistry and physics and basic courses in slide rule calculations, drafting, engineering literature and Russian (optional) are also available. After completion of the two-year course students are required to submit a thesis to earn their degrees.

Business Training College, the pre-charter name of Point Park, was founded in 1933 by Dr. Dorothy C. Finkelhor as one of the first schools in the country to specialize in the training of medical secretaries. The first technical secretary class of three entered in 1955; in June 1960, 70 engineering secretaries were graduated.

During the first five years of the program, students were drawn primarily from the Pittsburgh area. Now that the school has achieved junior college status, the student body is expected to have nationwide distribution.

Tuition at the school is about $2000 for the two-year course; however, the student investment is quickly repaid. Engineering secretaries' starting salaries are $400 to $500 a month, compared to about $300 for graduates of standard secretarial schools.

1962 National Electrical Show Planned for New York Coliseum

The Sixth National Electrical Industries Show, covering all categories of electrical equipment, will be held from March 11 to 14, 1962 at the New York City Coliseum. Approximately 300 exhibit booths are expected to be reserved for displays of construction materials and apparatus, wiring devices, electric heating equipment and industrial electric tools.

The 1962 version of the electrical trade exposition, sponsored by the Eastern Electrical Wholesalers Association, is being produced by Harold R. Meyer, president of Electrical Living Shows, Inc. Exhibit space may be reserved by contacting Mr. Meyer at 477 Madison Ave., New York, N. Y.

The National Electrical Industries Show was first held in 1952. The 1961 show attracted approximately 22,000 representatives from the electrical industry and allied fields.

Pennsylvania Electric Show Scheduled for November 7-9

"Power Up for Progress and Profit" has been selected as the theme of the Eighth Industrial Electric Exposition sponsored by the Electric League of Western Pennsylvania. The Exposition will be held November 7-9, 1961 at the Penn-Sheraton Hotel in Pittsburgh.

The trade show was instituted in 1949 to acquaint specifiers, buyers and users of electrical equipment with the most recent developments in equipment designed to improve plant efficiency. Official opening of this year's Exposition is scheduled to be at a luncheon on November 7.

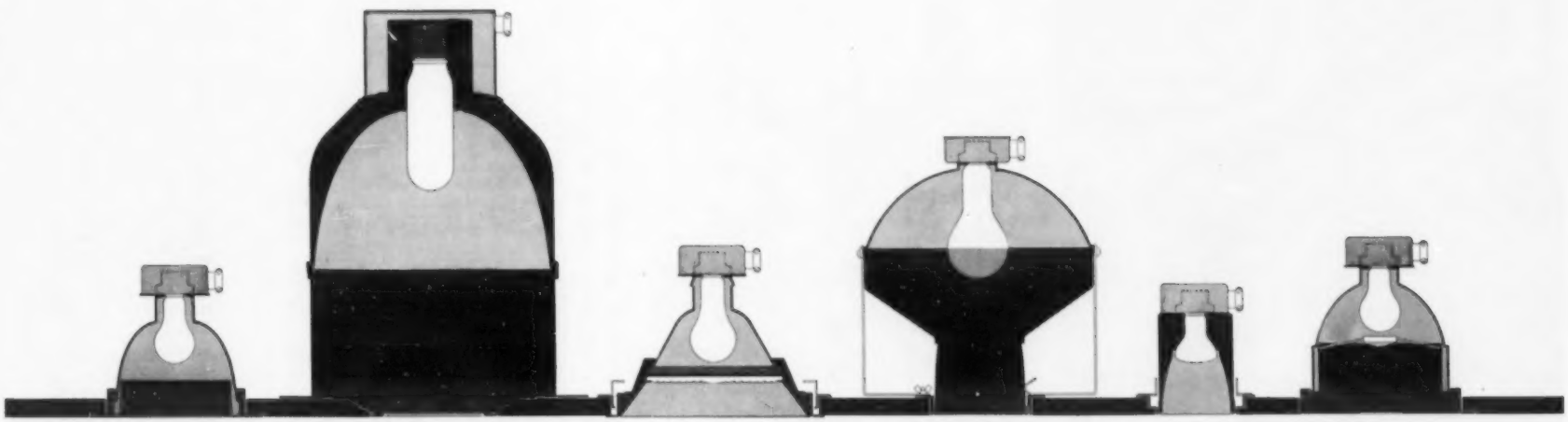
ABOUT PEOPLE

Parenthetical designations denote membership grade in the Society.

The board of directors of Corning Glass Works, Corning, N. Y. has announced the election of **Amory Houghton** as chairman of the company's executive committee. Mr. Houghton, who has been chairman of the board and chief executive officer of the company since 1941, will be succeeded in these positions by **William C. Decker,** Corning president since 1946. New president of the firm is **Amory Houghton, Jr.,** former staff vice president, who represents the fifth generation of his family to be associated with Corning since its establishment.

Phillip D. Pryne has been named president of the Emerson-Pryne Co., a subsidiary of Emerson Electric Manufacturing Co., St. Louis, effective April 1. Mr. Pryne succeeds **E. F. Kelly,** who has been appointed chairman of the board. **Ralph Pryne,** former board chairman, will continue to serve as a director of both Emerson Electric and Emerson-Pryne.

(Continued on page 15A)



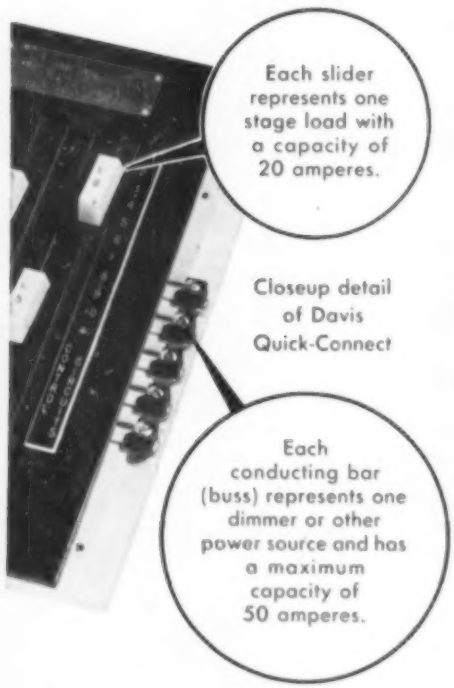
Shown here are cross-section drawings of six downlites designed and manufactured by Gotham Lighting. They are representative of some 680 units comprising the recessed downlite group. They are but one segment of more than 1050 different fluorescent and incandescent luminaires produced by Gotham Lighting. Each unit is the result of optical development and photometric testing. Each unit is engineered to specific requirements of lighting and construction. For comprehensive data on all Gotham Lighting equipment, with candlepower distribution curves, coefficients of utilization and efficiencies, as well as photographs, detailed drawings and specifications, a catalog is available on request. Gotham Lighting Corporation, 37-01 Thirty-first St., Long Island City, N. Y.

DAVIS QUICK-CONNECT®

Circuit selection at your finger tips.

(WALL OR CONSOLE MOUNTED)

Here are the most significant advancements in cross-connecting systems in 50 years:


Each slider represents one stage load with a capacity of 20 amperes.
Closeup detail of Davis Quick-Connect
Each conducting bar (buss) represents one dimmer or other power source and has a maximum capacity of 50 amperes.

1. **Finger-tip control** permits connection of as many as 60 different stage loads with any one of 40 possible separate power sources. In large installations several may be combined for greater capacity.
2. **Visible Programming.** Programming can be visibly checked without tracing individual circuits through a maze of patch cords.
3. **No-flicker patching.** No electrical contact is made until slider is released at desired load connection.
4. **"Dead front" construction** insures completely safe operation without danger of electrical shock.
5. **A sweep of the hand clears the board.** There are no plugs, jacks or cords to get lost or become worn and dangerous.

ARIEL DAVIS MANUFACTURING COMPANY

Dept. E261, 3687 South State Street, Salt Lake City 15, Utah

DAVIS DIMMER

LIGHTING ARTISTRY AT YOUR FINGERTIPS

(Continued from page 12A)

Maurice M. Rosen, president of Progress Manufacturing Co. of Philadelphia, has been re-elected president of the American Home Lighting Institute. **Jack Goldberg,** president of Jay Manufacturing Co., Inc., Brooklyn, N. Y., and **William B. Epling,** Prescolite Manufacturing Corp., Berkeley, Calif., were elected as vice-presidents. Re-elected as managing director was **Ted Cox,** president of Ted Cox Associates, Chicago, Ill.

The Edwin F. Guth Co., St. Louis, has announced the election of **Russell R. Viehman** (A) as vice-president. He succeeds **George Watts** (M), who retired on March 1 after 51 years of service to the company. **Kurt Kleindienst** has been named advertising manager, the position formerly held by Mr. Viehman.

The election of **Thomas Hollingsworth** as vice-president in charge of sales has been announced by Hubbard and Co., Chicago, Ill. Formerly, Mr. Hollingsworth served the company as sales manager.

J. E. Wagner (M) has been named as lighting engineer for the Ohio Highway Department. In the past, he has served as lighting engineer for the city of Cleveland and in sales and sales engineering capacities for the Lighting Department of the Line Material Co., East Stroudsburg, Pa.

The formation of an electrical engineering consulting firm in Milwaukee, Wis., has been announced by **George E. Dolan** (M) and **Thomas B. Dustin** (M). Formerly, Mr. Dolan served as lighting engineer for the Wisconsin Electric Power Co. and Mr. Dustin was associated with A. C. Electric, Inc., both of Milwaukee.

Effective April 1, **W. E. Schwanhausser** (A) joined the Automatic Signal Division of the General Electric Co., East Norwalk, Conn. Prior to assuming his new position, Mr. Schwanhausser was associated with the company's Outdoor Lighting Department, Hendersonville, N. C. Recently appointed to that department was **Dan C. Kyker,** who assumed the newly created post of manager of materials. Mr. Kyker will be responsible for the Outdoor Lighting Department's purchasing, shipping and receiving activities. Also announced by G-E was the appointment of **R. F. Quinn** as manager of the company's realigned Agency and Distributor Sales Development Operation. Mr. Quinn will make his headquarters in Schenectady, N. Y.

(Continued on page 18A)

SCHEDULED EVENTS

1961 Dates of Interest to IES Members

June

June 2-3—Maritime IES Conference, Moncton, N. B.

June 5-7—Edison Electric Institute, Annual Convention, New York, N. Y.

June 5-9—Society of the Plastics Industry, National Conference, Commodore Hotel, New York, N. Y.

June 6-7—IES Council Meeting, Barbizon Plaza Hotel, New York, N. Y. Members are invited to attend meetings as guests of Council.

June 8-9—Northeastern Regional Conference, IES, Berkeley-Carteret Hotel, Asbury Park, N. J.

June 18-23—American Institute of Electrical Engineers, Summer General Meeting, Ithaca, N. Y.

June 19-20—Great Lakes Regional Conference, IES, Sheraton-Gibson Hotel, Cincinnati, Ohio.

June 26-28—American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Denver-Hilton Hotel, Denver, Colo.

July

July 4-7—National Society of Professional Engineers, Annual Meeting, Olympic Hotel, Seattle, Wash.

July 18-20—Western Plant Maintenance Show, Pan Pacific Auditorium, Los Angeles, Calif.

August

August 21-23—National Association of Lighting Maintenance Contractors, National Convention, Flamingo Hotel, Las Vegas, Nev.

September

September 12-15—Industrial Building Exposition, New York City Coliseum, New York, N. Y.

September 14-15—Engineering Management Meeting, sponsored by AIEE and ASME, Hotel Roosevelt, New York, N. Y.

September 24-29—Illuminating Engineering Society, National Technical Conference, Chase-Park Plaza Hotel, St. Louis, Mo.

October

October 4-6—Canadian Electrical Manufacturers Association, Annual Meeting, Sheraton-Brock Hotel, Niagara Falls, Ont.

October 4-6—International Association of Electrical Leagues, Annual Conference, President Hotel, Atlantic City, N. J.

October 9-10—United States National Committee, CIE, Annual Meeting, Olentangy Inn, Columbus, Ohio.

October 10-12—American Standards Association, National Conference on Standards, Rice Hotel, Houston, Texas.

October 10-13—National Electrical Contractors Association, Annual Convention and Exposition, Washington, D. C.

October 15-20—American Institute of Electrical Engineers, Fall General Meeting, Detroit, Mich.

October 18-20—Optical Society of America, Annual Meeting, Biltmore Hotel, Los Angeles, Calif.

November

November 16—National Electrical Manufacturers Association, Annual Meeting, New York, N. Y.

Remaining 1961 IES Regional Conferences

Region	Date and Place	Chairman
Northeastern	June 8-9 Berkeley-Carteret Hotel Asbury Park, N. J.	Bruce J. Jensen Public Service Electric & Gas Co. 80 Park Place Newark, N. J.
Great Lakes	June 19-20 Sheraton-Gibson Hotel Cincinnati, Ohio	H. K. Flint 2926 Debreck Ave. Cincinnati, Ohio

Another **NEW** General Electric Ballast Development . . .

THIS CAPACITOR IS DESIGNED TO PREVENT RUPTURE!

New Thermal Link deep within capacitor roll protects against excessive internal temperatures which may cause rupture of the capacitor case. Also, a new bushing assembly acts as an effective barrier to seal against bushing seepage. Result: longer ballast life.

Introducing

NEW GENERAL ELECTRIC *Bonus Line*

Fluorescent Ballasts

DESIGNED TO...

- **eliminate hazards to people and property**
- **eliminate need for individual ballast fusing**
- **eliminate leakage**
- **provide longer ballast life**
- **be interchangeable with standard models**

WITH NO SACRIFICE IN SOUND PERFORMANCE!

Another **NEW** General Electric Ballast Development . . .

SPECIAL THERMAL PROTECTOR makes ballasts safer than ever before!

Unique Thermal Protector is designed to de-energize the ballast *permanently* at end-of-life failure, preventing compound softening and eliminating ballast leakage. This assures full-life protection against hazards to people or property.

General Electric proudly announces new Bonus Line fluorescent ballasts designed to offer you—for the first time—full protection against the hazards sometimes associated with ballast end-of-life failure.

This new ballast design, *available in most popular ratings for indoor commercial and industrial applications,* features two outstanding new General Electric developments that make it safer than standard ballast designs:

1. A new Thermal Protector has been developed and tested for several years in General Electric laboratories. The Thermal Protector de-energizes the ballast before it reaches the critical internal temperatures at end of life that cause ballast filling compound to soften or melt. This non-resetting Thermal Protector completely eliminates any need for individual ballast fusing.
2. A newly developed, two-way improved General Electric capacitor features a unique Thermal Link designed to overcome capacitor rupture and leakage which sometimes occur at end of life. Also, the new capacitor has a new bushing assembly which contributes to longer ballast life.

New Bonus Line ballasts are dimensionally, thermally, and electrically interchangeable with standard General Electric ballasts of same ratings. They meet—*and, in certain respects, exceed*—all appropriate industry standards. And you get all these ballast added values without sacrifice in sound performance. General Electric ballasts are still the quietest ballasts available!

In short, new G-E Bonus Line ballasts give you added years of safe, reliable, quiet performance. They're engineered to eliminate leakage, smoke—even the more violent conditions which sometimes occur at end of normal ballast life.

Your General Electric ballast sales engineer will be proud to give you full information on new G-E Bonus Line ballasts for your lighting applications. Contact your nearby G-E sales office or write for Bulletin GEA-6912 to Section 403-01, General Electric Co., Danville, Illinois.

HOW TO SPECIFY

To obtain the protection advantages of the new General Electric Bonus Line ballast features, specify "Ballasts shall be protected with non-resetting thermal protectors in the core and coil assembly and in the capacitor."

Progress Is Our Most Important Product

GENERAL ELECTRIC

Installations in the News...

One Side Mercury Street Lighting

Adequate illumination for light traffic and sufficient spill light to ensure safety in a two-block parking area on the west side of this Sanger, Calif. street are provided by a system of 250-watt improved-color mercury luminaires. The fixtures are mounted on 30-foot poles with modified bracket arms on approximately 78-foot centers along the east (business) side of the street.

System provides .5 to .8 footcandle on the pavement with good vertical illumination. Convenience outlets on standards can accommodate decorative lighting.

Photo and data are courtesy of Pacific Gas & Electric Co., Fresno, Calif.

(*Continued from page* 15A)

R. M. Swetland (A) has been appointed to the newly created post of illuminating engineer for the design section of the Pennsylvania Department of Highways. Mr. Swetland retired in 1958 from the General Electric Co., with which he had been associated for 35 years.

The Consumers Power Co., Muskegon, Mich., has appointed **Herbert E. Speiler** to succeed **George E. Korten** (M) as general street lighting supervisor. Mr. Korten, active in IES activities since 1929 and long a member of the Street Lighting Committee, retired after 47 years with the company. He plans to remain active in a consulting capacity.

Wilbur Riddle (M), resident architect of the General Electric Lighting Institute, Nela Park, Cleveland, delivered the 1961 Lectureship on Architecture and Lighting at the School of Architecture, University of Toronto. The annual lectureship, sponsored by J. A. Wilson Lighting and Display, Ltd., Toronto, in cooperation with the university, is designed to stimulate a more active interest in the role which light plays in design and architecture.

The appointment of **John M. DeMunn, Jr.,** as supervisor of customer service for the eastern sales district has been announced by the Corning Glass Works' Technical Products Division. Mr. DeMunn will be headquartered in the company's New York office.

The Radiant Lamp Corp., Newark, N. J., has announced the appointment of **Harold A. Erickson** as sales manager. Formerly, Mr. Erickson served as assistant northeastern region sales manager of the Westinghouse Lamp Division.

The Advance Transformer Co., Chicago, Ill., has named The Powers and Powell Co. to handle distributor sales in Ohio, effective April 1. Field personnel for Powers and Powell will be **E. C. Powell, Robert J. Liskay** and **Ray Thomas,** all of Cleveland, and **Robert O. Riffle,** of Dayton, Ohio. Advance has also announced the appointment of Colcock-Strickland and Co. as representatives for Louisiana and Mississippi. Their personnel include **Hutson Colcock** (M), New Orleans, **Lacy D. Cook,** Baton Rouge, La., and **William L. Strickland** (A), Jackson, Miss.

Deaths

N. A. Kozlarek, Cornhusker Section
Bong Ng, Yosemite Chapter
James Rainey, Milwaukee Section

HELPFUL LITERATURE

Color Anodized Aluminum Grilles, AIA File No. 14-B-6, available from Morris Kurtzon, Inc., 1420 South Talman, Chicago 18, Ill. 12 pp.

Several new patterns and applications of colored aluminum anodized grilles and screens, some for luminous ceilings and luminous walls are described and illustrated in this booklet. Installation data, construction drawings and architect's renderings accompany the application suggestions.

The booklet also demonstrates the architectural application of the grilles as decorative elements in building facades, stair railings and partitions. Six colored and several black and white photographs are included.

Area Floodlighting Made Easy, Bulletin 2719-1959, available from Crouse-Hinds Co., Syracuse, N. Y. 16 pp.

Handy tables in this booklet guide the floodlighting designer in his choice of quantity and type of floodlight, pole and fixture arrangement, heavy duty or general purpose, mercury or incandescent units. Footcandle distribution charts for various types of heavy duty and general purpose, mercury and incandescent fixtures are also included. Two pages of drawings show a variety of suggested mounting arrangements on walls, wood or steel members, flat surfaces, crossarms, pipe-top and utility poles.

Outdoor Projection of Giant Images, Brochure 240-B, available from Genarco Inc., 97-04 Sutphin Blvd., Jamaica, N. Y. 8 pp.

Detailed description and drawings illustrating the method of projecting giant images outdoors on white walls, billboards or translucent screens with a 3000-watt slide projector are contained

(*Continued on page* 22A)

Grantmoor Par-Three Golf Course — Newington, Connecticut

Patented

You can shoot birdies all night when Wide-Lites light the course!

There's a revolution in golf these days — a revolution that is making it a day *and night* game. As a result, more players can enjoy the sport, players whose work kept them from the course during daylight hours during the week. Floodlighting a course opens up a tremendous new revenue potential!

But floodlighting for golf requires the finest floodlighting — lights that give daytime visibility without glare. At the Grantmoor par-three course shown above, 43 1000-watt Wide-Lites are used, with each green lighted by two units, and each fairway lighted by two or three. The lights are mounted 35 to 40 feet above grade level, on wood poles.

Color-corrected mercury vapor Wide-Lites, with their broad light pattern, give ideal sports lighting, free from annoying shadows or "hot spots." The Wide-Lite is ideal from an economy view, too — the rugged cast aluminum body and tempered glass lens protect the lamp and reflector . . . lamps last 9 to 12 times longer than incandescents . . . and power requirements are low. Grantmoor's operators will save nearly $2,500 a year by using Wide-Lites instead of incandescent lamps!

Find out what Wide-Lites can do for your golf course or recreational area — just send the coupon!

WIDE-LITE

HIGH-EFFICIENCY FLOODLIGHTS

OUTDOOR AREA LIGHTS • VAPOR TITE MODELS • INDOOR WORK LIGHTS • MOBILE WORKING LIGHTS • SPORTS LIGHTS • PROTECTIVE LIGHTS

In Canada: Wide-Lite Division, Wakefield Lighting, Limited, London, Canada

WIDE-LITE CORPORATION Dept. Z11
P. O. Box 191 • Houston 1, Texas

Send more information on Wide-Lites for golf and other sports areas. No obligation, of course.

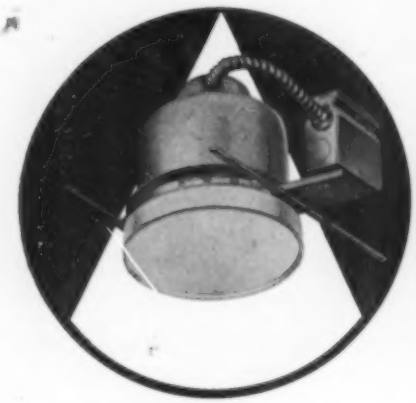
Name_____

Address_____

City_____ Zone_____ State_____

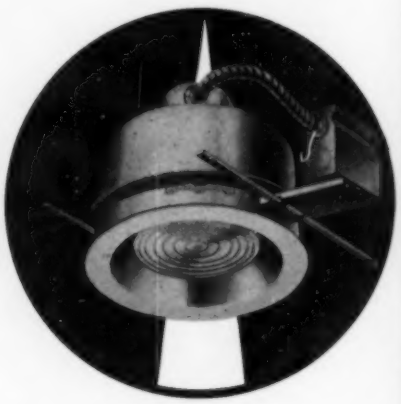
This is the embodiment of a design philosophy . . . a blending of function with aesthetics . . . a precisely engineered approach to every downlighting need. The product is *Calculite*, an impressive collection of 18 models of recessed incandescent fixtures . . . a total of 96 sizes and finishes, shapes and capacities. Each is designed for a *predictable* lighting effect, a particular design

DOWNLIGHTING EFFECTS



METAL SKIRT/ALBALITE

CLAREMONT



FLOATING LENS

LIGHT

Jersey City 5, New Jersey / Showrooms: New York, Chicago, Dallas, Los Angeles

Calculites are stocked by these Authorized LIGHTOLIER Distributors:

ALABAMA
Birmingham:
Mayer Elec. Sup. Co.

ALASKA
Anchorage:
Northern Supply Co.

ARIZONA
Phoenix:
Brown Wholesale Elec.
Tucson:
Sunset Ltg. Fix. Co.

ARKANSAS
Little Rock:
Ashcraft Ltg. & Sup.

CALIFORNIA
San Francisco:
California Elec. Sup. Co.

COLORADO
Denver:
Central Elec. Sup. Co.

CONNECTICUT
Bridgeport:
B. M. Tower Co., Inc.
Hartford:
Deacon Light & Sup. Co.
New Haven:
Grand Light & Sup. Co.
New London:
United Elec. Sup. Co.
Stamford:
Marie Co.
Waterbury:
Starbuck Sprague Co.
Suburban Supply Co.

DISTRICT OF COLUMBIA
Washington:
Maurice Elec. Sup. Co.
National Elec. Wholesalers

FLORIDA
Miami:
Farrey's Whlse. Hdwe. Co.

GEORGIA
Atlanta:
Electrical Wholesalers
Noland Co.

HAWAII
Honolulu
Hawaiian Light & Sup. Co.

ILLINOIS
Chicago:
Efengee Elec. Sup. Co.
Englewood Elec. Sup. Co.
Merlo Elec. Sup. Co., Inc.
Noland Elec. Sup. Co.
Metropolitan Elec. Sup.
Steiner Elec. Co.
Wholesale Elec. Sup. Co.
Elgin:
Fox Elec. Sup. Co.
Rockford:
Englewood Elec. Sup. Co.
Springfield:
Springfield Elec. Sup. Co.

INDIANA
Ft. Wayne:
Hessman-Yarnelle Co.
Gary:
Englewood Elec. Sup. Co.
South Bend:
Englewood Elec. Sup. Co.

IOWA
Des Moines:
Weston Lighting, Inc.

KANSAS
Kansas City:
W. T. Foley Elec. Co.
Wichita:
Architectural Lighting, Inc.

KENTUCKY
Louisville:
Henry J. Rueff Co.

LOUISIANA
Baton Rouge:
Electrical Wholesalers Inc.
New Orleans:
Interstate Elec. Co.

MAINE
Bangor:
Standard Elec. Co.
Portland:
Holmes Elec. Supply Co.

MARYLAND
Baltimore:
Baltimore Gas Light Co.
Excello Public Serv. Corp.
Salisbury:
Ashcraft Elec. Sup. Co.

MASSACHUSETTS
Boston:
Boston Lamp Co.
Mass. Gas & Elec. Light Co.
Henry L. Walters, Inc.
Plainfield:
Carr Supply Co.
Springfield:
Arno Elec. Sup. Co.
Eastern Elec. Sup. Co.
Worcester:
Atlantic Elec Sup. Co.
Benjamin Elec. Sup. Co.

MICHIGAN
Detroit:
Madison Elec. Co.
Michigan Chandelier Co.
Filint:
Royalite Co.
Grand Rapids:
Purchase Elec. Sup. Co.
Jackson:
Electric Wholesale Sup. Co
Pontiac:
Standard Elec. Co.
Saginaw:
Schmorbeim Elec. Co.
Standard Elec. Sup. Co.

MINNESOTA
Duluth:
Northern Elec. Sup. Co.
Minneapolis:
Charles A. Anderson & Co.
North Central Elec. Distr. Co.
Northland Elec. Sup. Co.
St. Paul:
Lee Elec. Co.

MISSOURI
Kansas City:
Graco Elec.
St. Louis:
M. R. Clark
Springfield:
Southern Materials Co.

MONTANA
Great Falls:
Glacier State Elec.

NEBRASKA
Lincoln:
White Electric Supply Co.
Omaha:
Electric Fix. & Sup. Co.

NEVADA
Reno:
Western Elec. Distr. Co.

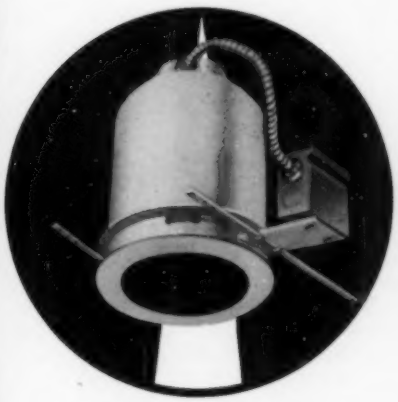
NEW HAMPSHIRE
Portsmouth:
Mass. Gas & Elec. Light Co.

NEW JERSEY
Atlantic City:
Franklin Elec. Sup. Co.
Cherry Hill:
Delaware Township:
Flynn's Camden Elec. Fix. Co.

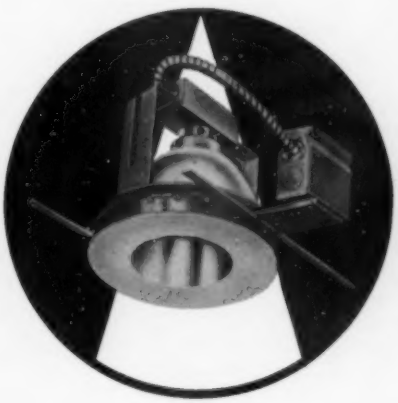
NEW MEXICO
Albuquerque:
The Lighting and Main. Co.

preference. Here is an opportunity to meet individual lighting needs on an almost custom basis. For instance, your choice includes wide, medium or concentrated light distribution from 30 to 300 watts, plus a wide array of baffles, bezels and reflectors. You'll find that their appearance and performance characteristics . . . in any combination . . . are typically Lightolier.

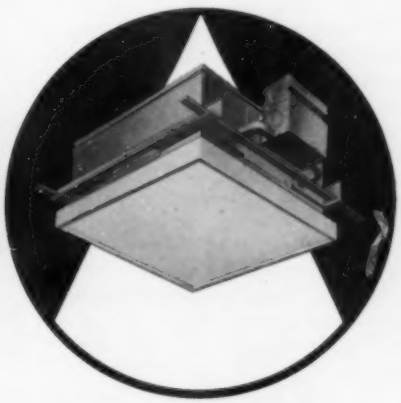
UNLIMITED: CALCULITES



MULTI-GROOVE BAFFLE



ELLIPSOIDAL



METAL SKIRT/ALBALITE

To learn more about Calculities, write today for a complete brochure to Dept. IE5

LIGHTOLIER®

...for a better way of Light

NEW YORK
Binghamton: Frank Elec. Sup. Co.
Buffalo: Buffalo Incand. Light Co. Inc.
Niagara Falls: Hazen Supplies Inc.
Poughkeepsie: Electra Sup. Co.
Rochester: Rowe Electric Sup. Co.
Syracuse: Superior Elec. Corp.

NORTH CAROLINA
Charlotte: Independent Elec. Sup. Co.
Durham: Noland Co.
Greensboro: Elec. Sup. & Equip. Co.
Kinston: Kinston Elec.
Raleigh Electrical Equipment Co.
Winston-Salem: Noland Co.

NORTH DAKOTA
Fargo: Northwest Elec. Sup. Inc.

OHIO
Akron: The Sacks Elec. Sup. Co.
Canton: Electric Sales Co.
Cincinnati: B. & B. Elec. Co.
F. D. Lawrence Electric Co.
Richards Elec. Sup. Co.
Cleveland: The H. Leff Electric Co.
Midland Elec. Co.
Columbus: Eigas Elec. Co.
The Loeb Elec. Co.
Dayton: Buehman Elec. Co.
Springfield: The W. W. Elec. Co.
Toledo: Gross Elec. Fix. Co.
Youngstown: The Graff Ltg. Fix. Co.

OKLAHOMA
Oklahoma City: Elec. Sup. of Oklahoma

OREGON
Portland: Baker-Barton Co.

PENNSYLVANIA
Allentown: Coleman Elec. Co.
Erie: Kraus Elec. Co.
Harrisburg: Fluorescent Sup. Co.
Schaedler Bros.
Hazleton: Power Elec. Co. Inc.
New Castle: Midwestern Elec. Co.
Philadelphia: Ace Lighting Fix. Co.
Gold Seal Elec. Sup. Co.
Sylvan Elec. Fix. Co.
Pittsburgh: Allied Elec Sup. Co.
Argo Lite Studios
Brown & Green
Wally Elec. Sup. Co.
Reading: Coleman Elec. Co.
Scranton: Lewis & Reif, Inc.
Uniontown: Pioneer Electric Dist.
Wilkes-Barre: Anthracite Elec.

RHODE ISLAND
Pawtucket: Major Elec. Sup. Co.
Providence: Leavitt Colson Co.

SOUTH CAROLINA
Columbia: Capitol Elec. Sup.
Noland Co.
Greenville: Sullivan Hdws. Co.

SOUTH DAKOTA
Watertown: J. H. Larson Elec. Co.

TENNESSEE
Knoxville: Square Elec Sup. Co.
Memphis: Belvedere Lighting Co.
Nashville: Nashville Elec. Sup. Co.

TEXAS
Dallas: Rogers Elec. Sup. Co.
Ft. Worth: Anderson Fixture Co.
Common Supply Co.
General Industrial Sup. Corp.
Houston: Anderson Lighting Co.
Gulf Coast Elec. Sup. Co. Inc.
Martin Associates
Southern Electric Supply Co.
Worth Elec. Sup. Co.
San Antonio: Southern Equip. Co.
Strauss-Frank Co.

UTAH
Salt Lake City: Artistic Lighting

VIRGINIA
Arlington: Dominion Elec. Sup. Co. Inc.
Noland Co.
Lynchburg: Mid-State Elec. Sup. Co., Inc.
Norfolk: Noland Co.
Roanoke: Noland Co.

WEST VIRGINIA
Clarksburg: Talley Engineering Co.
Huntington: West Virginia Elec. Co.
Wheeling: The Front Co.

WISCONSIN
Appleton: Nhd Northern Co.
Eau Claire: W. H. Hobbs Sup. Co.
La Crosse: W. A. Roosevelt Co.
Milwaukee: Electri-Craft Lighting
Lappin Electric Co.
Standard Elec. Sup.

WASHINGTON
Seattle: Seattle Lighting Fix. Co.

CANADA
Montreal: L. D. C. Products, Inc.
The Gray Elec. Co.
Union Electric Sup. Co. Ltd.
Toronto: Revere Elec. Dist.
Toronto Ltg. Studios

(*Continued from page* 18A)

in this publication. Rear projection of six- or seven-foot-wide images in brightly lighted areas is also discussed. Three handy tables list recommended image widths for a variety of surround lighting levels and projection distances for 20-, 30- and 40-foot images with 4.2- to 22-inch lenses.

How to Select and Apply Floodlights, Booklet GEA-6175C, available from General Electric Co., Schenectady 5, N. Y.

A comprehensive guide to floodlighting application, this booklet contains general principles of efficient floodlighting, a glossary of floodlighting terms, a table of floodlight classifications, application guide and calculation procedures. Sample calculations of footcandle levels provided by a floodlighting installation and solutions to floodlighting problems for building facades, signs and parking areas will provide a convenient reference for the lighting designer.

How to Work with Plexiglas, available from Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. 16 pp.

Detailed information on machining, forming, finishing and joining of Plexiglas sheets and other acrylic shapes is accompanied by more than 60 drawings illustrating processes employed in shaping the material. Machining operations discussed include layout, cutting, sawing, punching, drilling, routing, shaping and turning. Forming by hand, jig and clamp, plug and ring, drape, blow and vacuum methods, as well as hand and machine sanding, filing, scraping and buffing, receive extensive coverage.

Plastics for Lighting, AIA File No. 31F2, available from Holophane Co., Inc., 342 Madison Ave., New York, N. Y. 6 pp.

Designed to facilitate the specification of plastic lenses for lighting fixtures, this brochure presents, in tabular form, 16 properties of acrylic, polystyrene and vinyl plastics, as determined in recent laboratory investigations. Seven of these properties—light transmission, color stability, color stability—yellowing factor, outdoor exposure, resistance to cleaning agents, abrasion resistance and surface resistivity—are examined in a detailed discussion.

A table covering the variation in electrostatic properties of acrylic lenses with temperature and humidity and a general discussion regarding the use of plastics as a light shielding media are also included in the booklet.

It Seems to Me . . .

A Unified Lighting Theory

The excellent article on luminous walls in the March issue of IE (p. 123) unintentionally pointed out the problem involved in the integration of a variety of lighting elements for a total decorative effect. While all of the luminous walls shown were, in themselves, very attractive and appropriate decorative lighting elements, their effects in some of the rooms were marred by a lack of unified design.

For example, the ceiling in Mo and Junior's restaurant was so busy with *square* air conditioning ducts and *round* recessed pot lights with surface mounted trim that it detracted from the effect of the luminous walls. While esthetic judgment is largely a matter of individual opinion, it does seem that the use of square and round forms is contradictory and creates a weak total impression. I don't know what building problems were involved in the installation of the air ducts, but I do think that they could have been placed, unobtrusively, near the walls or in the corners of the room, or replaced with a less noticeable type.

Recessed round downlights with very little or no trim would have helped to eliminate the feeling of ceiling clutter; or square units blending with the square air conditioning ducts would have helped to create a unity of form in the ceiling elements. Eyeball units used to light plants and a piano were finished to blend with the ceiling material. Wouldn't recessed directional or wall washing fixtures have fulfilled the same lighting purpose with a more pleasing esthetic effect?

The luminous walls on the S.S. Constitution also suffer from the competition of the ceiling. Here again, surface trim on the downlights could have been eliminated with great benefit to the total interior design.

A third interior in the article showed beautiful lighted wall panels behind a TV/hi-fi unit which were marred by the addition of three suspended decorative fixtures. While I am not, on principle, opposed to decorative hanging fixtures, these must be considered in relation to the over-all interior design. Individual elements which are attractive must be rejected if they detract from the total effect—here, the luminous wall panels.

I appreciate that many times the interior decorator, architect or lighting engineer is in the peculiar position of acting only in an advisory capacity and is sometimes overruled by the owner of a building. However, I think the designer should have enough gumption to point out the pros and cons of various elements included in or excluded from lighting layouts.

It would appear that we still have to learn to coordinate forms, shape and light in relation to architectural design. We still do not know how to achieve a graceful blend of the many available fixtures in relation to architectural schemes and interiors. More detailed planning on the part of the architect, lighting engineer and interior designer is needed to develop lighting designs which will supply proper levels of illumination *and* be appealing in relation to the interior and its occupants. We in the lighting profession must adopt a more responsible attitude in our relationship to the architect, interior designer and owner of a building, not only in reference to the amount of illumination required, but also in the unification of lighting elements for the over-all harmony of the interior design. H. Gottlieb, *Modulite, Inc., Outremont, P.Q.*

Four Fundamental Aspects of Good Lighting, available from Gotham Lighting Corp. 37-01 Thirty-first St., Long Island City 1, N. Y.

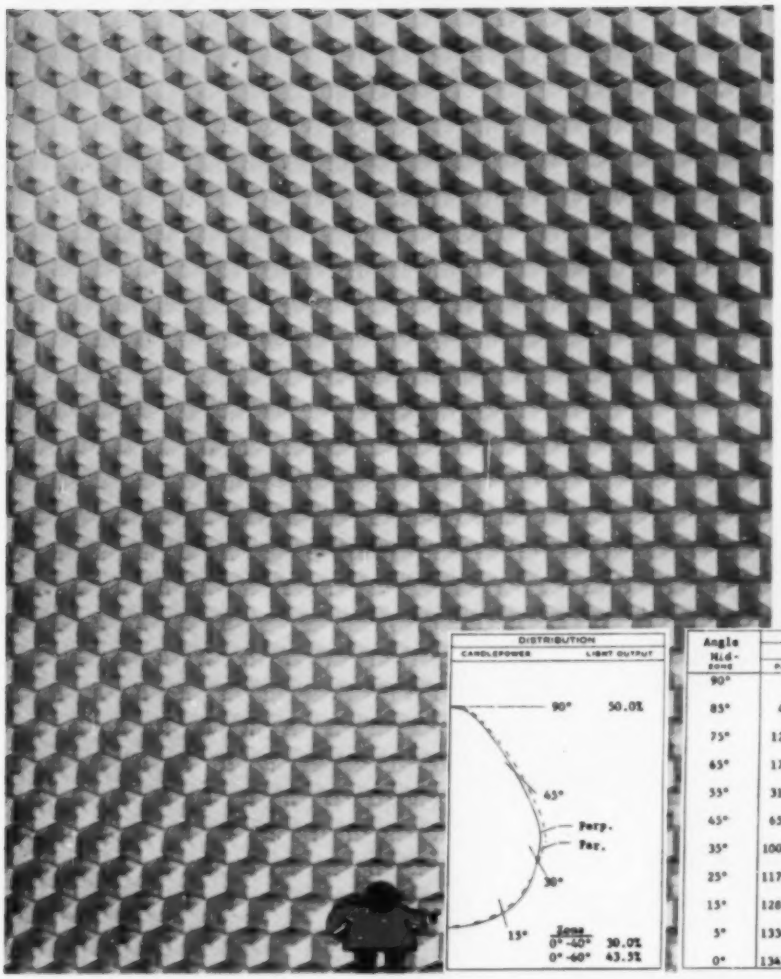
This pocket-sized, non-technical guide to basic principles of lighting design is a useful layman's introduction to the value of illuminating engineering. The booklet emphasizes the importance of brightness ratios in providing visual comfort, the psychological effects of the various colors of light, relation of brightness and contrast to ease of seeing and the use of directional lighting to delineate form and provide dramatic accents.

Group Relamping Plan, Booklet A-6832, available from Westinghouse Lamp Division, Bloomfield, N. J., 8 pp. No charge for single copies, quantity prices on request.

An introduction to group relamping, this pamphlet contains a general description of the advantages of a regular

(*Continued on page* 24A)

announcing the New EXTRU-LITE® Pattern R-7

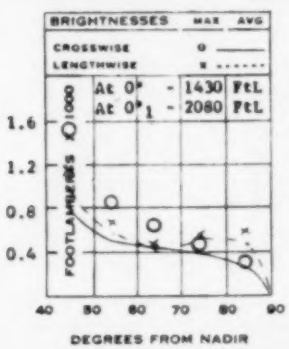


our famous plastic low brightness lensware — NOW extruded in a Brand NEW PATTERN.

Pattern R-7, with optically engineered hexagonal pyramids, permits the light to enter at all angles from the light source. It diffuses and refracts the light onto the work surface with a low brightness that is highly desirable for all types of visual tasks.

This 6-sided prismatic pattern controls, directs and reflects the rays to provide a glareless, more uniform light distribution.

Angle Mid-Zone	MID-ZONE CANDLEPOWER HORIZONTAL ANGLES PAR	22½°	45°	67½°	PERP	LUMENS
90°	0		0		0	-
85°	40.2		40.2		25.3	40
75°	127		125		96.9	125
65°	176		200		179	188
55°	317		313		279	274
45°	653		620		534	472
35°	1003		1000		970	625
25°	1177		1198		1196	551
15°	1281		1293		1301	365
5°	1334		1335		1338	127
0°	1341		1341		1341	-



IMPORTANT! Superior Advantage of Pattern R-7 over other hexagonal shapes: The secret of positive light control is in the *raised prisms*—it's *outstanding* in more ways than one.

Available immediately from stock up to 24" wide in Polystyrene or Acrylic.

Write or call our Dept. BK at our factory or our Sales Offices listed below today for Sample of Extru-Lite R-7. It's tougher, safer, and lighter than other materials.

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SUSTAINING membership certificate was presented to Al Kurtzon, Alkco Manufacturing Co., by IES President Richard G. Slauer, at a recent meeting of the Chicago Section.

(Continued from page 22A)

maintenance schedule, relamping programs for one-, two- and three-shift arens in old and new lighting installations and a cost comparison of group and spot relamping in a single-shift office where lamps are in operation 10 hours a day, 2500 hours per year.

Case history of a group relamping plan in a large office building demonstrates a saving of approximately $2200 in lighting maintenance costs over a two-year period.

Commercial Lighting Application Guide, Booklet L-101, AIA File No. 31F-237, available from Corning Glass Works, Corning, N. Y. 12 pp.

A guide to the use of glassware in lighting, this booklet describes the various types of glass available, characteristics and suggested lighting applications of each. Tables of recommended glassware for use with two-, three- and four-lamp troffers, luminous elements and recessed incandescent fixtures in office buildings, schools, banks, hospitals and stores also contain recommended illumination levels for these areas.

Lighting estimation tables present data for preliminary determination of lighting layouts and fixture number.

Adequate Highway Signing, Booklet OLP-1023, available from General Electric Co., Schenectady, N. Y. 18 pp.

General principles of sign lighting discussed in this pamphlet include brightness of sign panel in relation to surround, positioning and aiming of lighting unit for minimum glare and maximum sign visibility, reasons for the superiority of fluorescent over incandescent sign lighting and the advantages and disadvantages of top- and bottom-mounted lighting units. A sample calculation of the illumination level on a sign is illustrated with two drawings.

Appendixes include several application photographs and eight pages of photometric data for luminaires with and without covers, parallel and tilted.

NEW MEMBERS

At the meeting of the IES Council Executive Committee on April 12, 1961, the following were elected to membership. Names marked * are transfers from Associate Member Grade.

CANADIAN REGION

Bluenose Chapter

Associate Members:
Courtney, C. J., Nova Scotia Light & Power Co. Ltd., Halifax, N. S.
Dean, A. T., Martin & Dean Ltd., Halifax, N. S.
Martin, C. D., Martin & Dean Ltd., Halifax, N. S.
Richard, R. J., Nova Scotia Light & Power Co. Ltd., Halifax, N. S.
Story, R. M., Canadian Comstock Co. Ltd., Dartmouth, N. S.

Forest City (London) Chapter

Associate Member:
Musgrave, S., Lighting Maintenance Service Windsor, Ont.

Golden West Chapter

No Elections

Hamilton Ontario Chapter

No Elections

Maritime Chapter

No Elections

Montreal Section

Member:
Perron, G., Hydro-Quebec, Montreal, Que.
Associate Members:
Ferland, L., L. C. Barbeau Inc., Montreal, Que.
Peron, R. E. S., Nor-Ren Co. Ltd., Montreal, Que.
Romagnino, R., City of Montreal, Montreal, Que.
Tsapras, A. K., Canadian Broadcasting Corp., Montreal, Que.

Northumberland Chapter

No Elections

Ottawa Section

No Elections

Quebec Chapter

No Elections

St. Maurice Valley Chapter

No Elections

Toronto Section

Member:
*Watson, G. T., Amalgamated Electric Corp. Ltd., Toronto, Ont.
Associate Members:
Bruce, R. J., Sola-Basic Products Ltd., Toronto, Ont.
Harshaw, T. A., John H. Ross & Associates, Toronto, Ont.
Ketvirtis, A., Foundation of Canada Engineering Corp. Ltd., Toronto, Ont.
Third, D. G., Pyle-National (Canada) Ltd., Toronto, Ont.

Winnipeg Chapter

Associate Member:
Stirrett, D., C & M Products, Winnipeg, Man.

EAST CENTRAL REGION

Capital Section

Member:
Carson, J. A., General Electric Co., Washington, D. C.
Associate Member:
Willard, R. H., Jr., Architects Office, U. S. Capitol, Washington, D. C.

Eastern Pennsylvania Section

Member:
*Hendrix, W. T., Wolf & Hahn, Architects, Allentown, Pa.
Associate Member:
Joost, F. W., Pennsylvania Power & Light Co. Lancaster, Pa.

(Continued on page 26A)

SCHOOL lighting meetings, sponsored by Golden West Chapter in Regina and Saskatoon, Sask., featured talks by John M. Chorlton, chairman of the IES school lighting committee. Among the 50 in attendance at the Regina meeting (photo at left) were, l. to r.: Ernie Bolton, manager, Electric Service League; L. H. Ritenburg, chapter chairman; Rene Champagne, Electrolier Mfg. Co.; (Mr. Chorlton) Norman Baker, electrical contractor; Tom McGorrian, Northern Electric Co. At the Saskatoon meeting: Dave Thorpe, local IES representative; Norman Baker, L. H. Ritenburg, John Chorlton and Rene Champagne. Thirty people attended the Saskatoon meeting.

New incandescent Downlight line

NOW, CUSTOM QUALITY IN A STANDARD LINE

Contemporary styling, quick installation, easy maintenance, long, trouble-free life — the traditional advantages Frink has always built into its Custom line, are the criteria of this new Standard line. ■ Tastefully designed, precision engineered and quality constructed in the four basic types fundamental to most architectural requirements. ■ Included are square and round frames, eyeball and low-brightness aperture types in 75 to 300 watt sizes and many types of shielding — dished opal, Fresnel lens, Alba-lite 55, louvers, and apertures of various sizes. Choice of prewired or unwired units. ■ These customized downlights are available nationally from Westinghouse distributors.

WHEN YOU WANT TO SPECIFY QUALITY —

SPECIFY **Westinghouse by**

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Ask your Westinghouse Sales Representative for Westinghouse by FRINK Catalog FR 2, or write directly to: THE FRINK CORPORATION—211 63rd Street, Brooklyn 20, N.Y.

Installations in the News...

Mercury Lighting for Show Windows

One of the first reported applications of mercury lamps to show window lighting has proved highly successful and economical at the new Kitty Kelly shoe store in Paterson, N. J. Improved color 400-watt mercury lamps combined with 300-watt incandescent lamps (for color warmth) provide 300 footcandles at display level.

Both mercury and incandescent lamps are housed in fixtures recessed in the plywood-panel ceilings with decorative moldings used to conceal the junctions of fixtures and holes. Crystal glass reflectors, molded in the shape of a large inverted cup, have triangular cross section corrugations to direct lighting downward with a 120-degree conical pattern. Reflectors are encased in aluminum coverings to minimize dust accumulation on outer surfaces.

Advantages of the mercury lighting include lower installation, operating and maintenance costs. Photo and data are courtesy of Holophane Co., Inc., New York, N. Y.

(*Continued from page 24A*)

MARYLAND SECTION

No Elections

PHILADELPHIA SECTION

Associate Members:
Carson, R. E., 4356 Willow Ave., Oakford, Bucks County, Pa.
Donohoe, M. R., Philadelphia Electric Co., Ardmore, Pa.
Dotts, B. F., Philadelphia Electric Co., Norristown, Pa.
Featherer, R. M., Jr., Raymond M. Featherer, Electrical Contractor, Glenolden, Pa.
Fink, B., Barney Contracting Co., Philadelphia, Pa.
Frater, C. E., Frater's Electric Service Inc., Doylestown, Pa.
Goldman, R. H., 3832 Conshohocken Ave., Philadelphia, Pa
Irons, Y. H., Valley Forge, Pa.
Jones, R. S., Sears Roebuck & Co., Philadelphia, Pa.
Joseph, R. B., Philadelphia Electric Co., Philadelphia, Pa.
Keough, J. R., Robert Keough and Co., Philadelphia, Pa.
Moraux, E. A., R. L. Cunningham Electric Co., Philadelphia, Pa.
Morris, G. L., Morris Electric, Levittown, Pa.
Paul, S. H., Stan Paul Interiors, Philadelphia, Pa.
Phillips, J. M., 122 W. Cherry Ave., Trappe, Pa.
Ricci, A. N., A. E. D'Ambly, Architects Bldg., Philadelphia, Pa.
Teal, A. C., Philadelphia Electric Co., Chester, Pa.
Wright, R. D., Wright Service, Media, Pa.

PITTSBURGH SECTION

Associate Members:
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Fuellgraf, C. L., Jr., Fuellgraf Electric Co., Butler, Pa.

VIRGINIA SECTION

No Elections

GREAT LAKES REGION

BUCKEYE CHAPTER

No Elections

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MacIntire, R. G., Niagara Mohawk Power Corp., Syracuse, N. Y.

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Associate Members:
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Craig, E. L., General Electric Lighting Institute, Cleveland, Ohio.
Embrey, J. R., Ohio Power Co., Canton, Ohio.
Farling, R. J., Cleveland Electric Illuminating Co., Cleveland, Ohio.
Izzi, E. L., Westinghouse Electric Corp., Cleveland, Ohio.
Stigers, R. F., Elliott Electric Co., Cleveland, Ohio.
Swanson, H., Arthur G. McKee and Co., Cleveland, Ohio.
Vande Velde, H. J., Cleveland Electric Illuminating Co., Cleveland, Ohio.
Westermann, W. N., Westinghouse Electric Corp., Cleveland, Ohio.

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Pownard, P. E., Link Electric Co., Louisville, Ky.

MIAMI VALLEY SECTION

Associate Member:
Leidy, H. R., General Electric Supply Co., Dayton, Ohio.

MICHIGAN SECTION

Associate Member:
Davidson, C. A., Thermotank, Inc., Detroit, Mich.

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No Elections

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Johnson, J. S., Cincinnati Gas & Electric Co., Cincinnati, Ohio.

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*Miller, E. L., 122 Buckland Ave., Rochester, N. Y.
*Vincent, D. H., General Electric Co., Rochester, N. Y.
Gordon, R. M., Rochester Electrical Contractors Associates, Rochester, N. Y.
Simmons, R. C., Curtis AllBrite Lighting Inc., Rochester, N. Y.
Streby, H. E., New York State Electric & Gas Corp., Hornell, N. Y.

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Associate Member:
Michaelson, J. W., Loblaw Inc., Buffalo, N. Y.

INTER-MOUNTAIN REGION

ARIZONA SECTION

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Associate Member:
Bloomquist, W. C., Arizona Public Service Co., Douglas, Ariz.

NEW MEXICO CHAPTER

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Gill, A., Gill and Gill Associates, El Paso, Texas.

ROCKY MOUNTAIN SECTION

No Elections

SOUTHERN COLORADO CHAPTER

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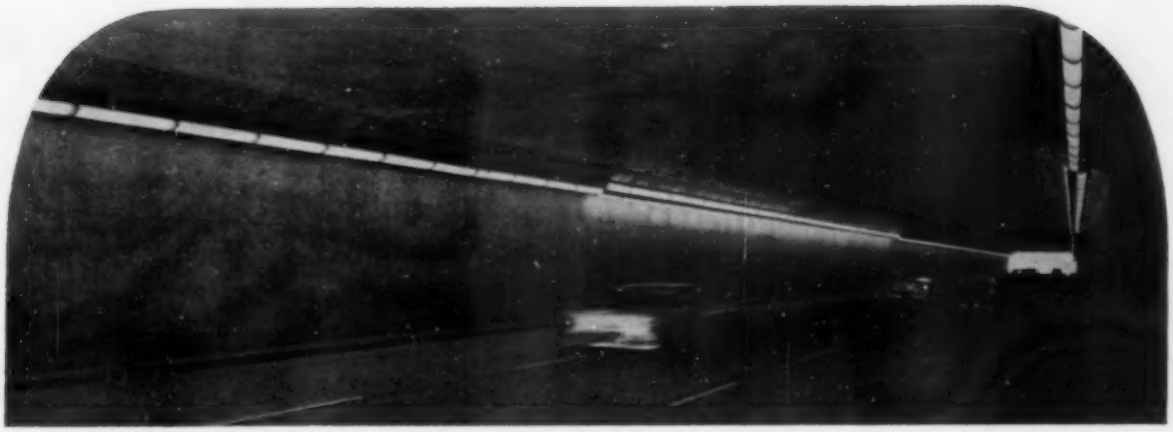
UTAH SECTION

Members:
*Huckins, W. A., Jr., The Sale Lake Hardware Co., Salt Lake City, Utah.
*Lowder, J. W., Stevens Sales Co., Salt Lake City, Utah.

(*Continued on page 40A*)



PERFORMANCE-PROVED TUNNEL LIGHTING

15 years in the design, engineering and manufacture of lighting equipment for tunnels and underpasses positively qualifies Sunbeam Lighting Company national leadership in this intricate field. Thousands of fixtures in various parts of the country have withstood the harsh tests of time, weather, and extreme service conditions.

The most versatile and rugged lighting unit for tunnels, underpasses, loading docks, etc. is the 2200 SERIES. Operating at 430MA, 800MA, and 1000MA and all UL approved, these fixtures permit a wide range of illumination intensities. Units are available in 6-foot and 12-foot (nominal) lengths and may be installed in single or double rows. Thick aluminum extrusions and die castings assure built-in strength, rigidity, and corrosion-resistance. The curved, acrylic plastic diffuser is completely reinforced to prevent breakage and to facilitate maintenance. No other fixture of this type is as thoroughly gasketed as the 2200 series for moisture-resistant integrity and protection against dust and fumes. Heavy-gauge wireways may be mounted directly to tunnel walls on concrete inserts (by others) or on various brackets to meet a variety of installation conditions.

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SUNBEAM LIGHTING COMPANY

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ABOVE ALL:

lighting fixtures molded of LUSTREX® PERMA TONE

Gratelite Luminous Ceiling in Sayers Printing Company, St. Louis, Mo., manufactured by Edwin F. Guth Company, St. Louis; molded by Prolon Div., Prophylactic Brush Company, Florence, Mass.

Why is more Lustrex perma tone used for louvered ceilings than any other ultra-violet light-stabilized styrene? First, in clear white and a complete color range, perma tone exceeds IES-NEMA-SPI joint specifications for ultra-violet light-stabilized styrene. Second, you can illuminate large areas at low cost—with good diffusion, and uniform light distribution. Third, fixtures made of perma tone are light in weight, yet dimensionally stable.

There is also a new Impact Lustrex perma tone for extra toughness and flexibility for snap-fitting to metal parts, high resistance to abnormal abuse, lighter weight through thinner walls. For a comprehensive technical Report on both General Purpose and Impact Lustrex perma tone styrene—including accelerated aging test results and other valuable data on styrene in lighting—write to Monsanto Chemical Company, Plastics Division, Room 817, Springfield 2, Mass.

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MONSANTO INNOVATOR IN **PLASTICS**

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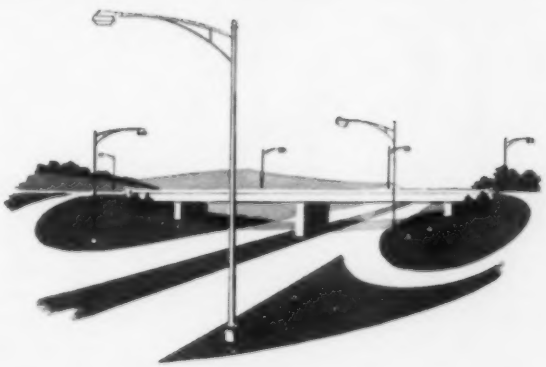
Monotube street lighting poles . . . steel or aluminum . . . round or fluted . . . davit or bracket styling . . . anchor or transformer base. Attractive in any location. Continuous-tapered Monotube poles are available in a broad range of designs and sizes to meet all requirements.

Monotube highway lighting poles are offered for various mounting heights and strength requirements. Easily wired and installed. Steel Monotubes are made from high grade, open hearth steel and cold-rolled for strength. Aluminum poles are either cold-rolled or spun.



Monotube floodlighting poles . . . for sports, business, industrial or recreational areas. Available in heights from 20 to 100 feet. Monotube designs permit extreme flexibility in arrangement and number of light units per pole. Floodlights can be mounted, positioned and wired while pole is on the ground.

Complete design and specification data is readily available upon request. Write The Union Metal Manufacturing Company, Canton 5, Ohio. In Canada: The Union Metal Manufacturing Company of Canada, Limited, Brampton, Ontario.

UNION METAL

Monotube Lighting Poles

SAINTS PHILIP AND JAMES CHURCH, CLEVELAND, OHIO • STICKLE & ASSOCIATES, ARCHITECTS

Rambusch designers, lighting engineers and craftsmen have developed a series of fixtures which are adaptable to most churches. Now beautiful and efficient luminaires for every outlet in the church can be furnished within modest budget allowances. The lantern shown above is made in four sizes with cream tinted diffusing glass cylinders 8", 10", 12 or 14 inches in diameter, rated at 200, 300, 500 and 750 watts respectively. Write for the Templite data sheet X-2.

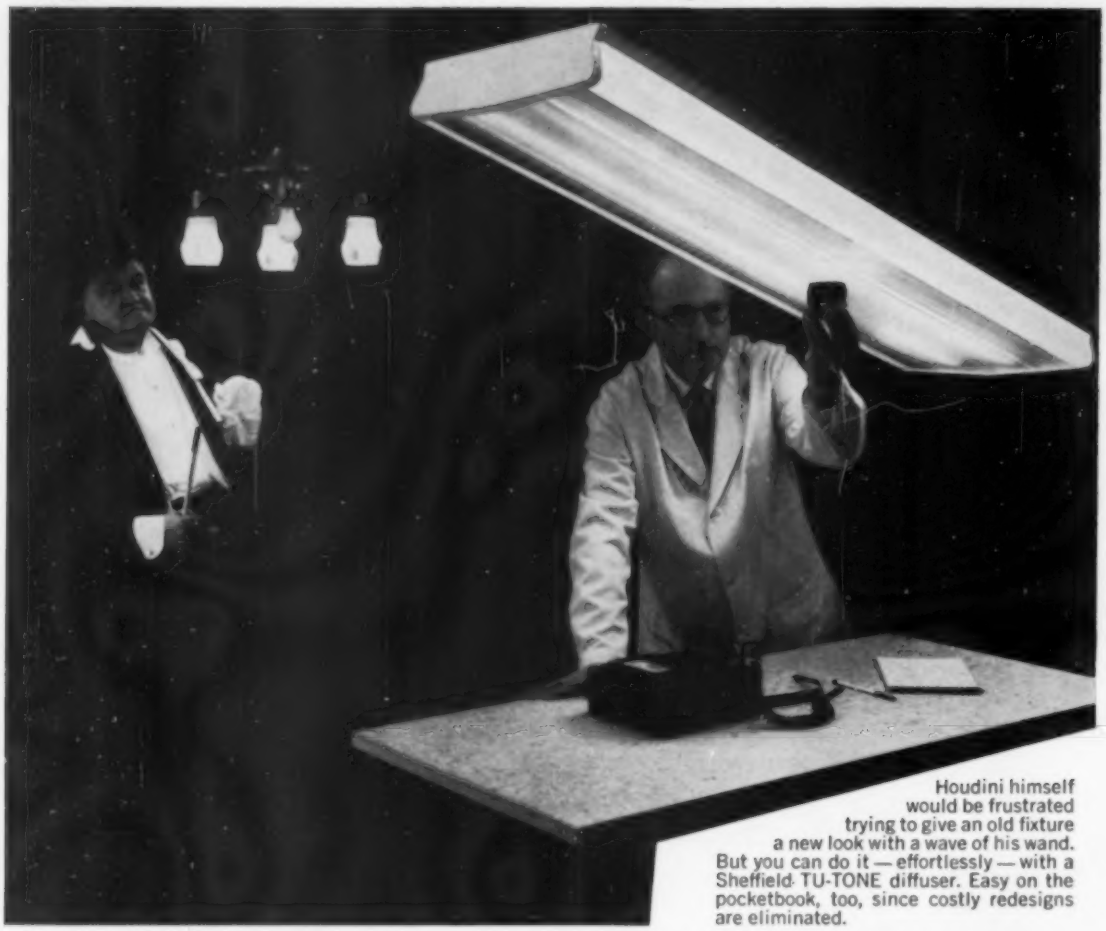
RAMBUSCH

40 WEST 13th STREET, NEW YORK 11, N. Y.

LIGHTING

SEPTEMBER 24-29, 1961

To give old fixtures a Magical New Look--



Houdini himself would be frustrated trying to give an old fixture a new look with a wave of his wand. But you can do it — effortlessly — with a Sheffield TU-TONE diffuser. Easy on the pocketbook, too, since costly redesigns are eliminated.

SHEFFIELD'S TU-TONE* DIFFUSERS

Sheffield's custom designed TU-TONE diffusers are a sure way to beat the profit squeeze. Easily adapted to new or existing designs, they provide a modern two-color effect at a cost comparable to single color styrene diffusers.

The clear, prismatic bottom is a Sheffield "exclusive". It provides excellent 45-degree cut-off and concentrates transmitted light down on work surfaces for maximum efficiency. TU-TONE diffusers available with all types of return legs for hinging purposes too.

MORE INFORMATION about TU-TONE diffusers or other Sheffield "exclusives" such as FROST-WHITE-X, FROST-WHITE-SE, DIRECTO-LITE or SL-series Prismatic Lenses is readily available. Direct your inquiries to Sheffield Plastics, Inc., Section 11-B, Sheffield, Mass.

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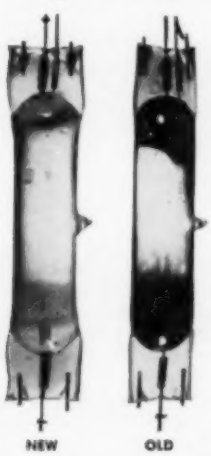
First from General Electric (1958)... another bright idea that became a better lamp... Bonus Line Mercury

works 6,000 hrs. overtime, cuts your customers' costs

Nearsighted Mister Magoo says . . ."1958? How time flies! That's the year the Nautilus—gallant lads!—went under the North Pole, and General Electric developed the Bonus Line Mercury lamp. Happy birthday, Bonus Line. Egad! Who built the ship in this bottle?"

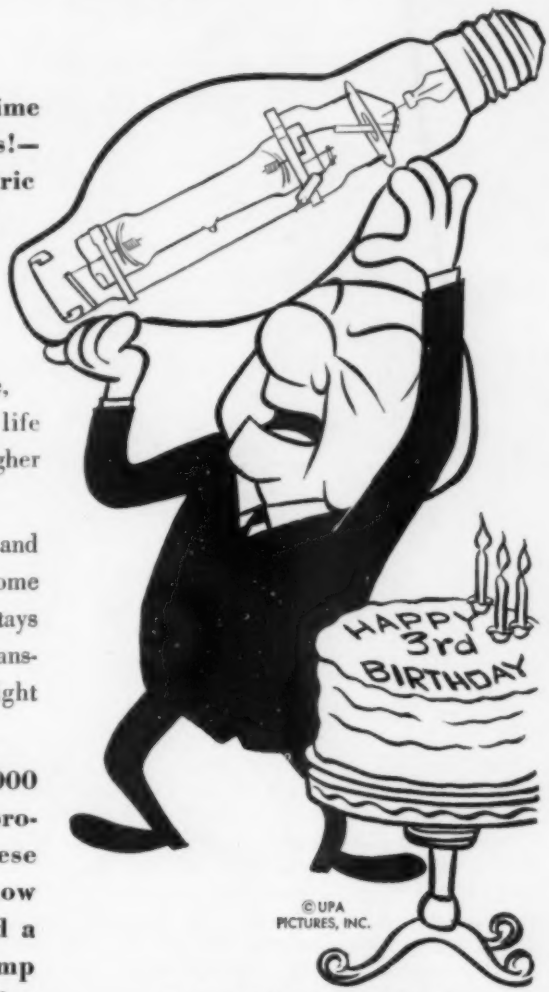
Look again, Mister Magoo. It's General Electric's special new electrode. Up through the 400-watt size, it gives your customers 12,000 hours of useful life —*or twice as much as the old non-bonus line.* And the higher wattages (700 and 1000) offer 50% extra useful life.



Compare these two arc tubes, and you'll see where the extra hours come from. Notice how the new one stays white instead of blackening. The translucent *white* deposit lets more light come through.

Result: more light after 12,000 hours than ordinary lamps produce after 6,000 hours. These extra hours are free. And now manufacturing efficiencies and a growing demand for this lamp enable us to reduce its price 15%. Other popular G-E 400-watt mercury lamps are reduced 8-13%.

Important: All G-E mercury lamps are now made only in *heat resistant glass,* to prevent glass deterioration. Ask your G-E distributor for more details. General Electric Company, Large Lamp Dept. C-19, Nela Park, Cleveland 12, Ohio.



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new SOLA outdoor mercury-lamp transformer

provides parallel protection

. . . plus constant-wattage stability!

Here's the big improvement you've waited for in *mercury lamp ballasting:* a really stable, *parallel-type,* constant-wattage, *2-lamp* transformer. Even if one lamp burns out, this new SOLA transformer keeps the other shining steadily.

And SOLA's *constant-wattage performance* protects both lamps and wiring against surge current . . . forestalls flicker by providing complete electrical independence between paired lamps; also, automatically compensates for line-power fluctuations. And the modest starting demand of SOLA constant wattage allows you to install more fixtures per circuit without having to step up wire sizes. The cost advantages are obvious in such installations as: parking lots, shopping centers, service stations, and dock areas.

Contact your SOLA representative for details on new 2-lamp outdoor constant-wattage MV transformers, as well as the other indoor and outdoor alternative units. Or write for information, mentioning *parallel MV outdoor transformer.*

- "Paralleling" ends double lamp-outages
- Exclusive constant-wattage design holds lumen output within ±1% for line-voltage changes as great as ±13%, assuring full-rated lamp life
- Prevents "drop-out" since input voltage must fall 30% below nominal before lamps extinguish
- Inherent protection against open or short-circuited lamps
- U.L. listed
- Available for 115, 208, 230, 277, 460 and 575-volt input

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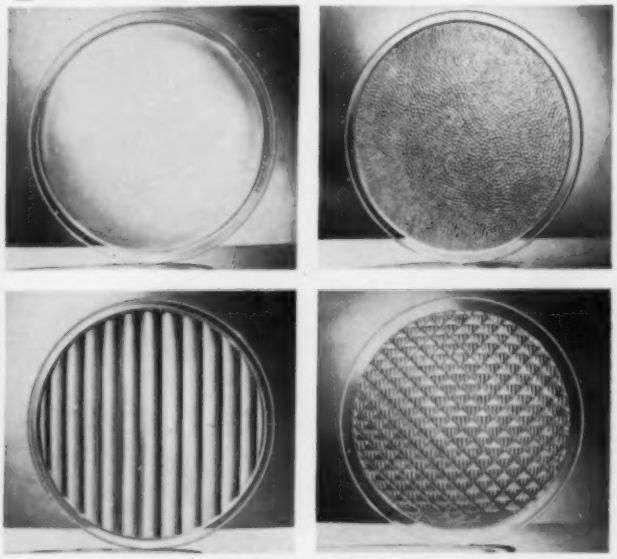
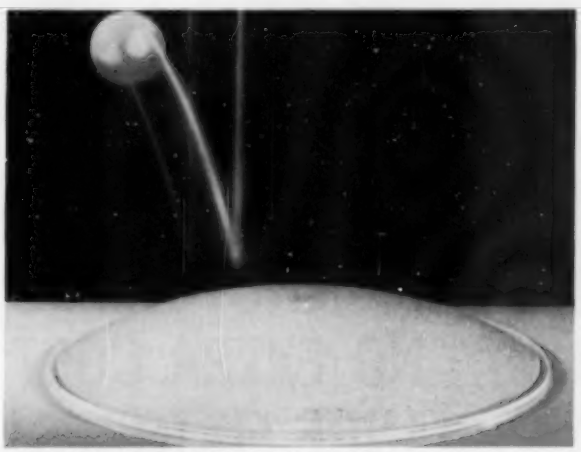
and high transmission glassware are achieved through control of glass composition, mold design and custom production.



EXACT LIGHT TRANSMISSION and DISTRIBUTION
of prismatic or fresnel-type lenses and roundels—provide concentrated, condensed, diffused, spread or deflected beam patterns.



INCREASED MECHANICAL STRENGTH
is accomplished by developing special compositions, annealing and tempering. The ball-drop test is used to determine resistance to impact.

HIGH THERMAL SHOCK RESISTANCE
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Perhaps Kopp can help you. Write us about your lighting problem. Early consultation may save you time and money.

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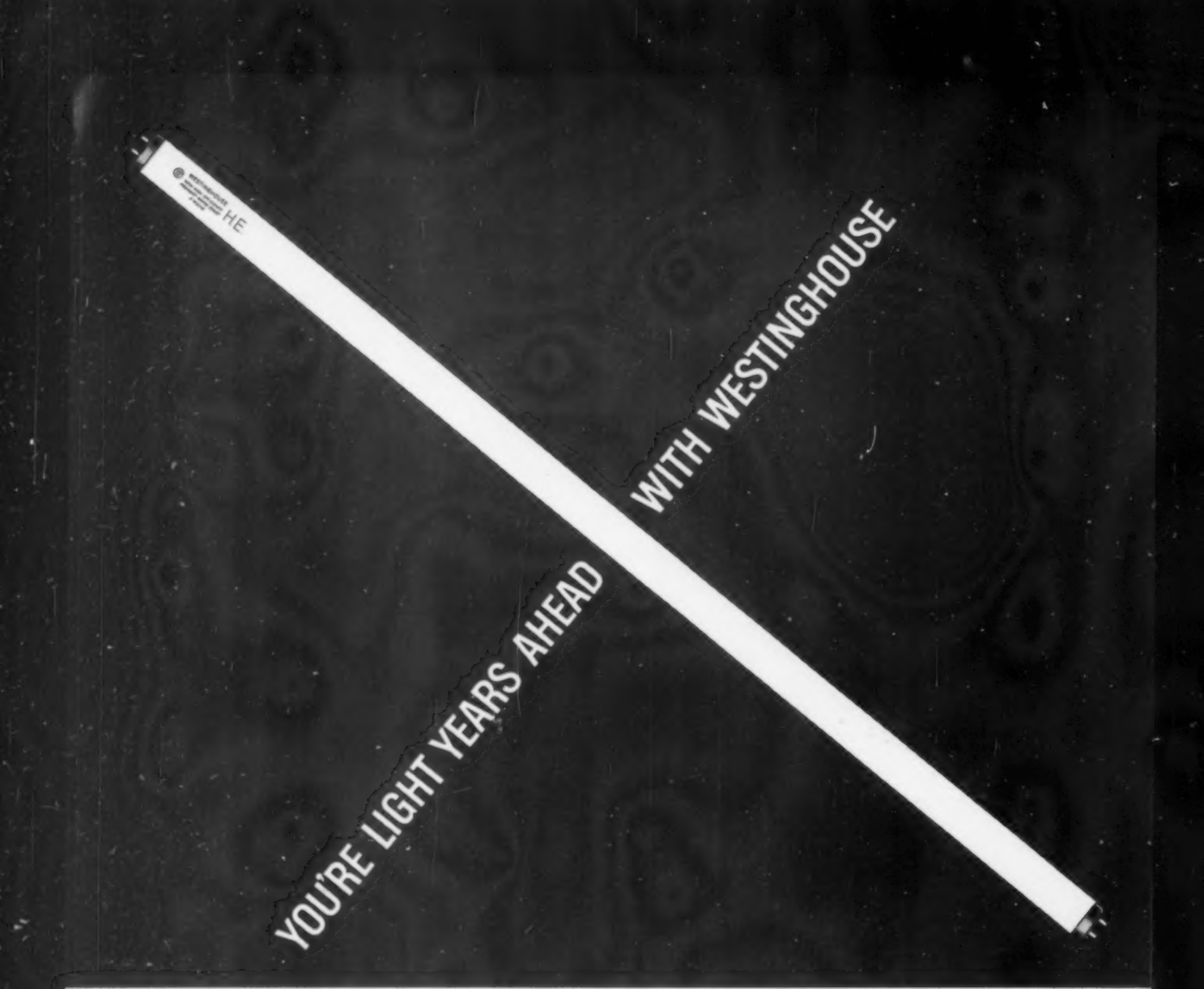

NEW WESTINGHOUSE HIGH-EFFICIENCY LAMPS GIVE YOU ⅓ MORE LIGHT AT NO EXTRA COST AND YOU DON'T HAVE TO CHANGE FIXTURES!

Now you can increase lighting levels without changing a single fixture . . . without increasing power costs . . . and without paying premium lamp prices. New Westinghouse "High Efficiency" fluorescent lamps give you a full third more light than daylight lamps . . . and 15% more light than cool white lamps . . . without consuming an extra watt of power!

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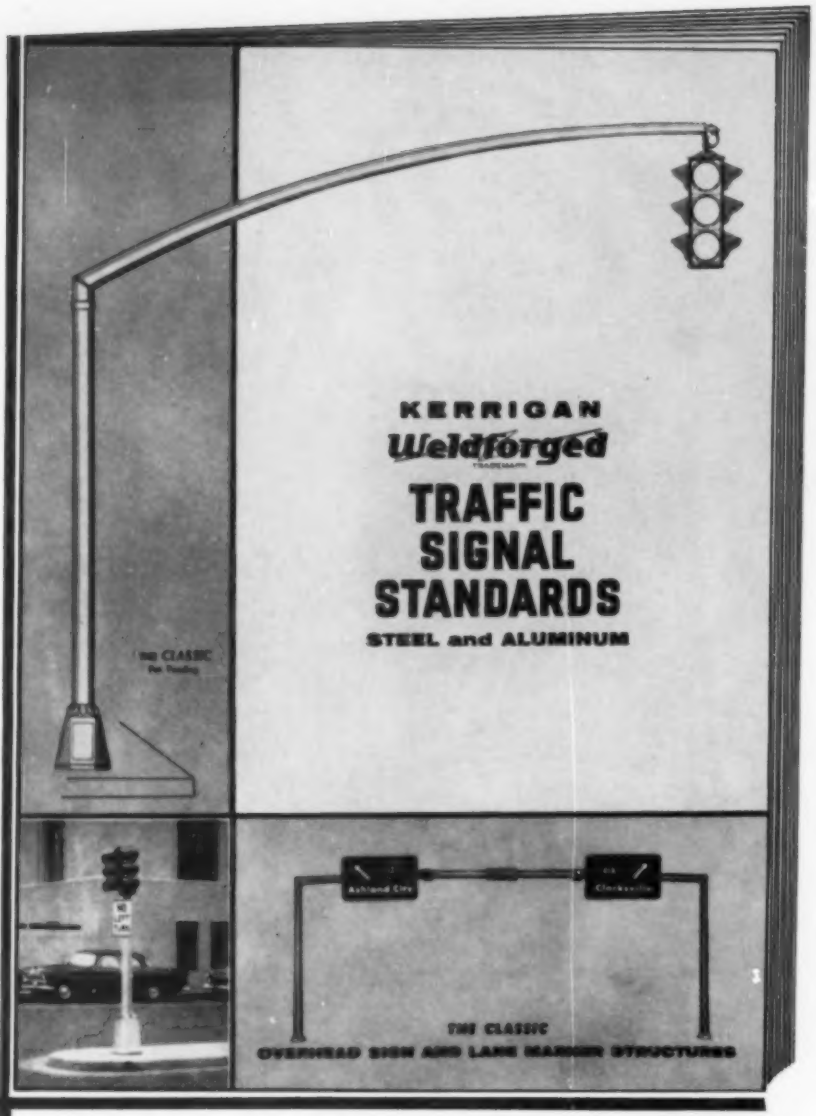

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Get YOUR copy of the new catalog pictured here! Choose from the *latest* in traffic signal and sign supports!

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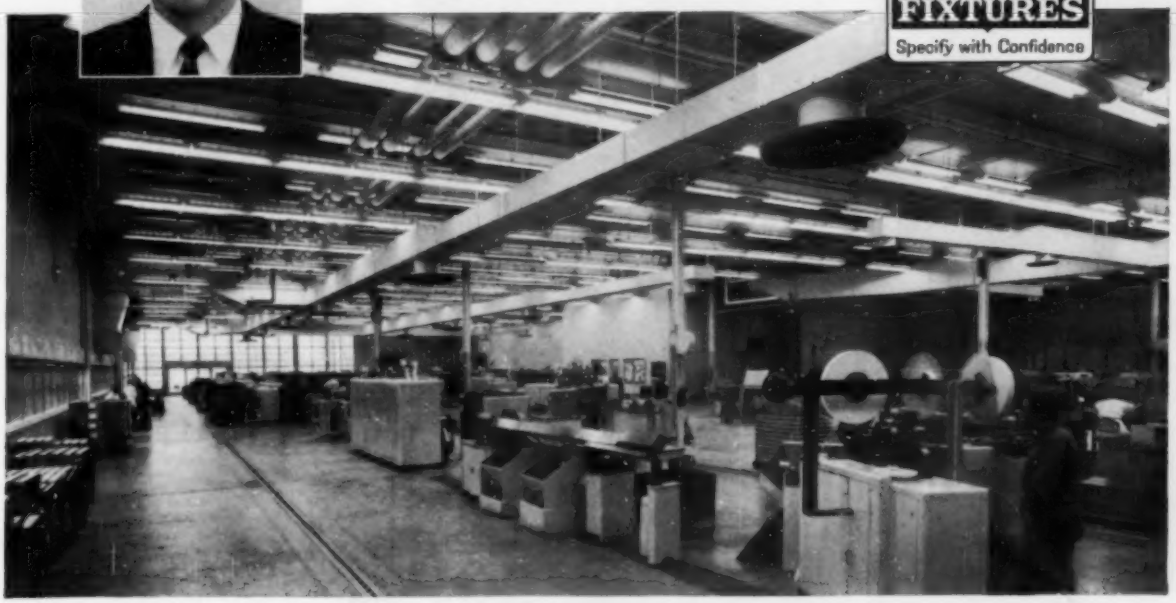
"We're very pleased with this Sylvania lighting installation," states John Haas, Supervisor of Electrical Engineering at Johnson & Johnson's New Brunswick plant. "Our production facilities have a cleaner appearance. We maintain our equipment easier and with greater safety. And our employees are much happier working under this new lighting."

SYLVANIA Lighting FIXTURES
Specify with Confidence



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First Aid for Production and Maintenance at Johnson & Johnson

At Johnson & Johnson's New Brunswick, N.J. plant—the home of Band-Aid Adhesive Bandages—clean surroundings, fast inspection and ease of mechanical maintenance are essential.

To maintain high efficiency in the manufacturing, processing and packaging of Band-Aid Plastic Strips, Johnson & Johnson recently installed new Sylvania industrial fixtures using Sylvania VHO Powertube lamps.

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Sylvania's industrial fixtures using 1500 ma lamps have led to increased production, less waste and better overall efficiency in many plants.

If *your* production figures are not what you expect, take a close look at your lighting. And look to Sylvania fixtures to solve your lighting problems.

VITAL STATISTICS
Johnson & Johnson, New Brunswick, N.J.
Fixture Type—Sylvania 1500 Ma Industrial Units (Slotted Porcelain Reflector—10% upward component)
Lamp Type—Sylvania F96T12/CW/VHO (1500 ma)
Mounting Height—14'
Fixture Spacing—10'
Average Illumination—150 Footcandles

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(Continued on page 42A)

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- Ballasts and fixtures that operate within U/L temperature limits . . . positive protection against overtemperature, overcurrent, or both.
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- Maximum ballast life . . . external faults can not cause dangerous overheating. When corrected, ballast operates normally again. An internal fault signals need for ballast replacement . . . with protector keeping temperature at a safe level until this is convenient.
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Ballasts equipped with KLIXON Protectors can be supplied to your fixture manufacturer by all six leading makers of ballasts. Simply use specifications shown here. Write for full engineering details.

USE THIS KLIXON PROTECTION SPECIFICATION

"Ballast shall be thermally protected against overheating by a built-in automatic reset overheat protector sensitive to both winding temperatures and current which will prevent winding temperatures from exceeding 120°C with the exception that the peak temperatures in the first few cycles may exceed this. The protector must allow the winding temperatures to reach 105°C minimum under normal conditions in a 40°C ambient without opening the circuit to the primary winding, and after opening shall not reclose above 85°C. Fixtures must be so designed that ballast coil temperatures shall not exceed the U/L limit of 105°C in a 40°C ambient."

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(Continued on page 44A)

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increase light levels scientifically skylens*
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Pleasant **natural** light from color corrected lens

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Frink Corp.	25A
General Electric Co., Apparatus Div.	16A-17A
General Electric Co., Large Lamp Dept.	33A
Gotham Lighting Corp.	13A
Edwin F. Guth Co.	Back Cover
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Monsanto Chemical Co.	28A
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Precision Multiple Controls, Inc.	43A
Rambusch Decorating Co.	30A
Revere Electric Mfg. Co.	2A
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Sheffield Plastics, Inc.	32A
Sola Electric Co.	34A
Stonco Electric Products Co.	42A
Sunbeam Lighting Co.	27A
Sylvania Electric Products Inc.	1A, 39A
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The electric power required to operate a 25 cent 100 watt incandescent lamp will amount to nearly $2.50 before the lamp burns out. The efficiency with which a lamp converts electric power into usable light is an important factor in considering lamp value.

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A 200 watt incandescent lamp produces approximately 3800 lumens. Two 100 watt incandescent lamps produce approximately 3400 lumens — about 10% less light.

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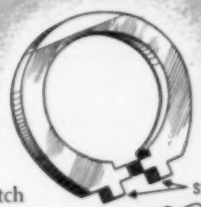

Completely assembled, installed in 5 seconds. Latch slips through hole, ring is snapped on. ¼ turn to operate. Spring tension eliminates noise transmission and vibration. Simple hole preparation. Eliminates riveting, screws, spot welding. Inexpensive.

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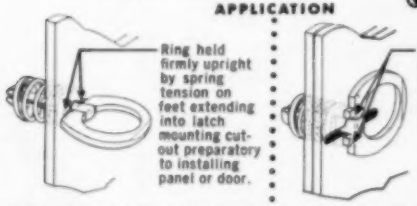
Ring held firmly upright by spring tension on feet extending into latch mounting cut-out preparatory to installing panel or door.
On completion of installation, ring held flat by feet extending beyond pivotal plane of ring.

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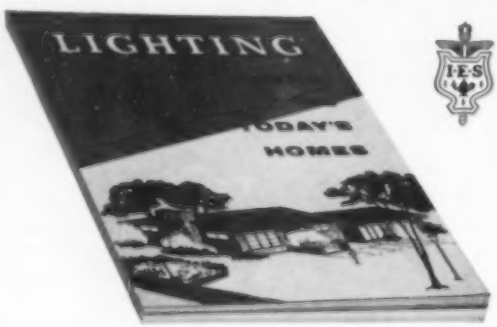

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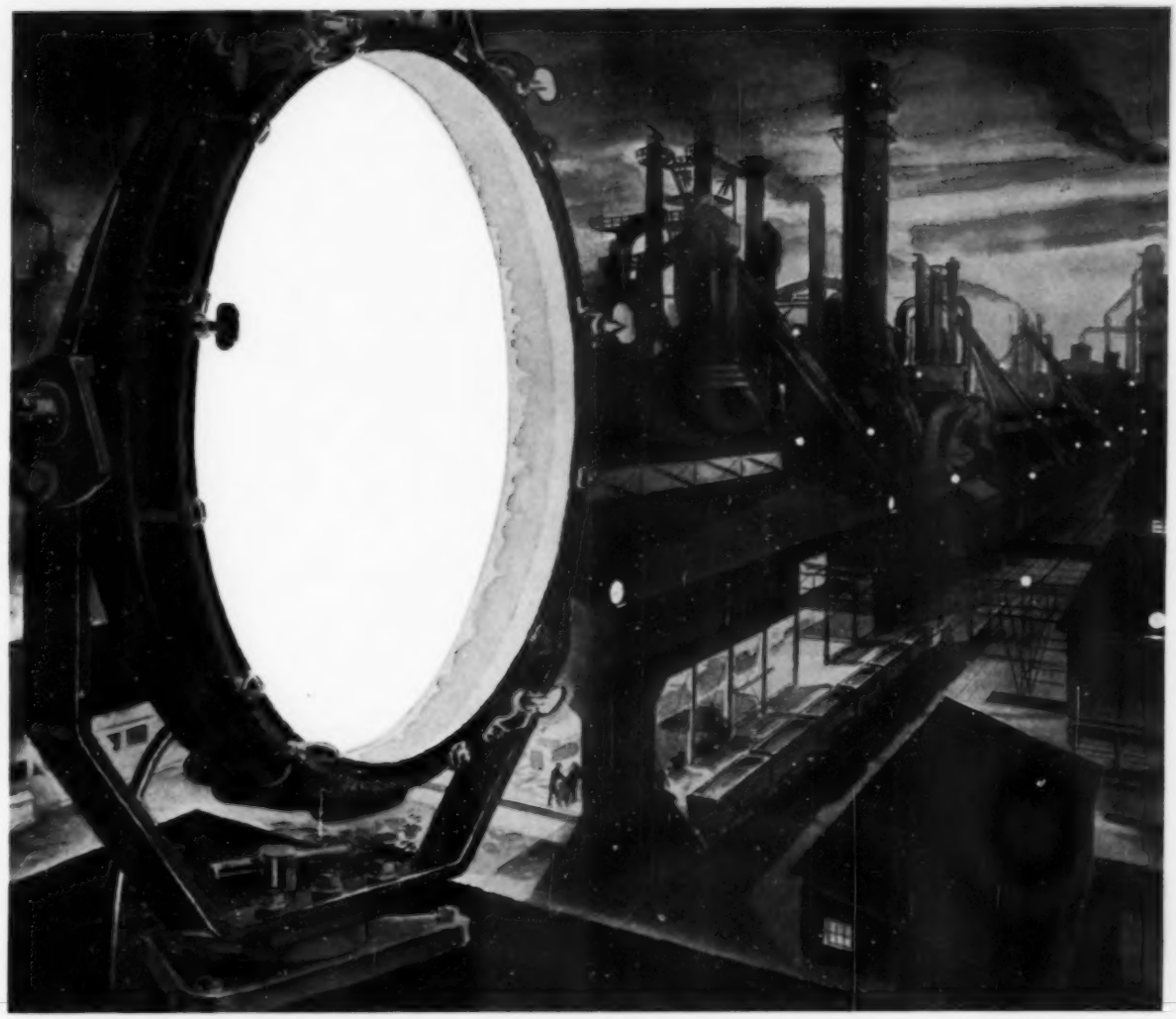

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When you buy a floodlight for heavy duty service, you want one that was specifically designed and constructed for that service.

Sheet or strip metal, for instance, does not fill the bill for heavy duty applications. We use it in the floodlights we make for *general purpose* applications, and these are available in many types where lighter construction is adequate.

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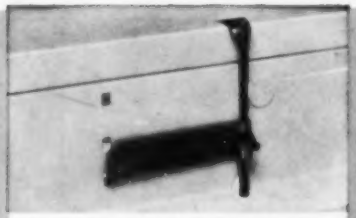

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